MISSILE DEFENSE AGENCY (MDA)
SMALL BUSINESS INNOVATION RESEARCH PROGRAM (SBIR)
SBIR 04.1 Proposal Submission Instructions

INTRODUCTION

The MDA SBIR program is implemented, administrated and managed by the MDA Office of Small and Disadvantaged Business Utilization (SADBU). If you have any questions regarding the administration of the MDA SBIR program please call 1-800-WIN-BMDO. Additional information on the MDA SBIR Program can be found on the MDA SBIR home page at http://www.winbmdo.com/. Information regarding the MDA mission and programs can be found at http://www.acq.osd.mil/bmdo.

For general inquiries or problems with the electronic submission, contact the DoD Help Desk at 1-866-724-7457 (1-866-SBIRHLP) (8am to 5pm EST). For technical questions about the topic during the pre-solicitation period (1 Oct through 30 Nov 03), contact the Topic Authors listed under each topic on the http://www.dodsbir.net website before **1 December 2003.**

As funding is limited, MDA will select and fund only those proposals considered to be superior in overall technical quality and most critical. MDA may fund more than one proposal in a specific topic area if the technical quality of the proposal is deemed superior, or it may fund no proposals in a topic area.

PHASE I GUIDELINES

MDA intends for Phase I to be only an examination of the merit of the concept or technology that still involves technical risk, with a cost not exceeding $100,000.

A list of the topics currently eligible for proposal submission is included in this section followed by full topic descriptions. These are the only topics for which proposals will be accepted at this time. The topics originated from the MDA Programs and are directly linked to their core research and development requirements.

<u>Please assure that your e-mail address listed in your proposal is current and accurate. MDA cannot be responsible for notification to companies that change their mailing address, their e-mail address, or company official after proposal submission.</u>

Phase I Proposal Submission

<u>Read the DoD front section of this solicitation for detailed instructions on proposal format and program requirements</u>. When you prepare your proposal submission, keep in mind that Phase I should address the feasibility of a solution to the topic. Only UNCLASSIFIED proposals will be entertained. MDA accepts Phase I proposals not exceeding $100,000. The technical period of performance for the Phase I should be 6 months. MDA will evaluate and select Phase I proposals using scientific review criteria based upon technical merit and other criteria as discussed in this solicitation document. Due to limited funding, MDA reserves the right to limit awards under any topic and only proposals considered to be of superior quality will be funded.

If you plan to employ NON-U.S. Citizens in the performance of a MDA SBIR contract, please identify these individuals in your proposal as specified in Section 3.5.b (7) of the program solicitation.

It is mandatory that the <u>ENTIRE</u> technical proposal, DoD Proposal Cover Sheet, Cost Proposal, and the Company Commercialization Report are submitted electronically through the DoD SBIR website at http://www.dodsbir.net/submission. If you have any questions or problems with the electronic proposal submission contact the DoD SBIR Helpdesk at 1-866-724-7457.

This <u>COMPLETE</u> electronic proposal submission includes the submission of the Cover Sheets, Cost Proposal, Company Commercialization Report, the ENTIRE technical proposal and any appendices via the DoD Submission site. The DoD proposal submission site http://www.dodsbir.net/submission will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. Your proposal submission must be submitted via the submission site on or before the 6 a.m.15 January 2004 deadline. Proposal submissions received after the closing date will not be processed.

PHASE II GUIDELINES

This solicitation solicits Phase I Proposals. MDA makes no commitments to any offeror for the invitation of a Phase II Proposal. Phase II is the prototype/demonstration of the technology that was found feasible in Phase I. Only those successful Phase I efforts that are **invited** to submit a Phase II proposal and all FAST TRACK applicants will be eligible to submit a Phase II proposal.

Invitations to submit a Phase II proposal will be made by the MDA SBIR Program Manager (PM) or one of MDA's executing agents for SBIR. Fast Track submissions do not require an invitation. Phase II proposals may be submitted for an amount normally not to exceed $750,000. Companies may, however, identify requirements with justification for amounts in excess of $750,000.

PHASE II PROPOSAL INVITATION

An MDA Program begins the process for a Phase II Invitation by making a recommendation (all MDA Topics are sponsored by MDA Programs). The MDA Program recommendation is based on several criteria. The Phase II Prototype/Demonstration (*What is being offered at the end of Phase II?),* Phase II Benefits/Capabilities (*Why it is important),* Phase II Program Benefit (*Why it is important to an MDA Program),* Phase II Partnership (*Who are the partners and what are their commitment? Funding? Facilities? Etc? This also can include Phase III partners*), and the Potential Phase II Cost. This is the basic business case for a Phase II invitation and requires communication between the MDA Program, the Phase I SBIR Offeror, and the Phase I Technical Monitor.

The MDA Program Phase II Invitation recommendation is made to the MDA SBIR Working Group. The MDA SBIR Working Group will review the Phase II invitation recommendations and make a recommendation to the MDA SBIR Steering Group based on the same criteria and the availability of funding. The MDA SBIR Steering Group will review and make their recommendation based on the same criteria as the MDA SBIR Working Group to the MDA Selection Official. The MDA Selection Official has the final authority. If approved by the MDA Selection Official then a Phase II Invitation is issued.

Phase II Proposal Submission

If you have been invited to submit a Phase II proposal, please see the MDA SBIR website http://www.winbmdo.com/ for further instructions.

All Phase II proposals must have a complete electronic submission. Complete electronic submission includes the submission of the Cover Sheets, Cost Proposal, Company Commercialization Report, the ENTIRE technical proposal and any appendices via the DoD Submission site. The DoD proposal submission site **http://www.dodsbir.net/submission** will lead you through the process for submitting your technical proposal and all of the sections electronically. Each of these documents are submitted separately through the website. Your proposal must be submitted via the submission site on or before the MDA specified deadline or may be declined. .

MDA FASTTRACK Dates and Requirements:

The complete Fast Track application must be received by MDA 120 days from the Phase I award start date. The Phase II Proposal must be submitted within 180 days of the Phase I award start date. Any Fast Track applications or proposals not meeting these dates may be declined. All Fast Track applications and required information must be sent to the MDA SBIR Program Manager at the address listed below, to the designated Contracting Officer's Technical Monitor (the Technical Point of Contact (TPOC)) for the contract, and the appropriate Execution Activity SBIR Program Manager.

Missile Defense Agency
MDA/SB Attn SBIR Program Manager
7100 Defense Pentagon
Washington, DC 20301-7100

The information required by MDA, is the same as the information required under the DoD FastTrack described in the front part of this solicitation. Phase I interim funding is not guaranteed. If awarded, it is expected that interim funding will generally not exceed $30,000. Selection and award of a Fast Track proposal is not mandated and MDA retains the discretion not to select or fund any Fast Track proposal.

MDA SBIR PHASE II ENHANCEMENT PROGRAM

To encourage transition of SBIR into DoD Systems, MDA has a Phase II Enhancement policy. While not guaranteed, MDA may consider a limited number of Phase II enhancements on a case-by-case basis. MDA will generally provide the additional Phase II enhancement funds by modifying the Phase II contract.

PHASE I PROPOSAL SUBMISSION CHECKLIST:

All of the following criteria must be met or your proposal will be REJECTED.

____1. Your technical proposal, the DoD Proposal Cover Sheet, the DoD Company Commercialization Report (required even if your firm has no prior SBIRs), and the Cost Proposal have been submitted electronically through the DoD submission site by 6 a.m. 15 January 2004.

____2. The Phase I proposed cost does not exceed $100,000.

MDA 04.1 Topic List

MDA04-001	Lightweight Energy Production and Storage for High Altitude Airships (HAA)
MDA04-002	Weight-Reduced Regenerative Fuel Cell Solutions for High Altitude Airships (HAA)
MDA04-003	Thin Film, Flexible Photovoltaic Arrays for High Altitude Airships (HAA)
MDA04-004	Propulsion and Propeller Technology for High Altitude Airships (HAA)
MDA04-005	Space Qualifiable Laser Technology
MDA04-006	Development of Micro-Scale Laser Technology
MDA04-007	Method for Generating a Corrected Beacon Using Non-linear Optics
MDA04-008	Advanced Guidance, Navigation and Control (GNC) Algorithm Development to Enhance the Lethality of Interceptors against Maneuvering Targets
MDA04-009	Miniaturized, Low Weight, Low Cost Interceptor Components for the Miniature Kill Vehicle (MKV)
MDA04-010	Boost Phase Plume-to-Hardbody Handover
MDA04-011	Data and evidence fusion from multiple independent Decision Theoretic sources: Hybrid Decision Networks
MDA04-012	Generalized Multivariate Decision Theory: Hyperspectral Target Detection in Remote Sensing Operations
MDA04-013	Laser Radar Algorithms
MDA04-014	Electro-Optical/Infrared Multi-frame Processing
MDA04-015	Super Resolution
MDA04-016	Advanced Discrimination Technologies and Concepts
MDA04-017	Reactive Materials as Lethality Enhancers
MDA04-018	Microsatellite Precision Guidance, Navigation, and Control Concepts
MDA04-019	Precision Propulsion Concepts for Microsatellites
MDA04-020	Innovative Techniques for Missile Defense
MDA04-021	Processing techniques for Multiple Wavelength Infrared Sensors
MDA04-022	Early Launch Detection, Booster Typing, and Kill Assessment Sensor Concepts
MDA04-023	Optimized Management of Multiple Networked Sensors
MDA04-024	Improvements in Infrared Scene Projection for Hardware-in-the-Loop (HWIL) Testing
MDA04-025	Visible/UV Image Projector for Sensor Testing
MDA04-026	Advanced Ladar Signature Modeling Techniques
MDA04-027	Advanced PC Scene Generation Techniques & Hardware Architectures
MDA04-028	Realtime Body Dynamic Antenna Modeled GPS/JAMMER Simulator for HWIL
MDA04-029	Analog Lightwave and Arbitrary Waveform Components for Ladar Scene Generation
MDA04-030	Novel Infrared Point Sources
MDA04-031	High Temperature Multi-Band Infrared scene Generation Technology
MDA04-032	Sensitivity analysis for missile defense battlespace environment simulation and scene generation
MDA04-033	Plume model verification via sensitivity analysis
MDA04-034	Technologies to Improve Software Acquisition/Development Process
MDA04-035	Innovative Manufacturing Process Improvements
MDA04-036	Manufacturing Technology for Radiation Hardened/Tolerant Systems
MDA04-037	Ballistic Missile System Innovative Power Storage Devices
MDA04-038	Ballistic Missile Innovative Electro-Optic Products
MDA04-039	Ballistic Missile Innovative Radar and RF Products
MDA04-040	Ballistic Missile Innovative Signal Processing, Data Fusion and Imaging Products
MDA04-041	Ballistic Missile System Composite Materials and Structures
MDA04-042	Adaptive Computing for Surveillance and Seeker Applications
MDA04-043	Unstructured Knowledge Integration for Range and Space Launch Support
MDA04-044	Fuselet Technology for Decision-Quality Missile Threat and Targeting Information
MDA04-045	Communication Alternatives for Missile Communications
MDA04-046	Reconfigurable Computing for Missile C4I
MDA04-047	Execution of High Level Specifications for Simulation Based Acquisition
MDA04-048	Reconfigurable Analog Electronics for Missiles Defense Elements
MDA04-049	Multi-Frequency Radar Discrimination
MDA04-050	Multiple Beam Klystron Electron Gun for Radar Applications

MDA04-051	Advanced Divert and Attitude Control Systems (DACS)
MDA04-052	Hypergolic Chemical Leak Detector
MDA04-053	Advanced Seeker Technologies
MDA04-054	Radar Data Fusion for Single Integrated Air Picture (SIAP)
MDA04-055	Innovative Approaches to Increase Power And Efficiency in Components Based on GaN or Other Materials Offering Performance Enhancements Exceeding that of GaAs, in X-Band Radars.
MDA04-056	Computer Network Operations (CNO)
MDA04-057	Electronic Techniques For Radiation Hardening of EKV Electro-Optics Subsystems
MDA04-058	Advanced Divert and Attitude Control (DACS) system for the Miniature Kill Vehicle (MKV)
MDA04-059	Define/Demonstrate Non-hazardous or Less Hazardous Beryllium (Be) Material for Defense Applications
MDA04-060	Performance Enhancement of In-Flight Interceptor Communications System (IFICS)
MDA04-061	Infrared (IR) Multispectral Imager for the Next Generation EKV
MDA04-062	Electronically Steerable IFICS Data Terminal Antennas
MDA04-063	Electronically Steerable Antenna for Kill Vehicle and Space Platforms
MDA04-064	Predictive Fault Detection & Isolation for Unmanned Communications Terminals
MDA04-065	Adaptive/Evolving Plans and Procedures for Casualty Recovery & Battle Continuity
MDA04-066	Software Modem for Kill Vehicle & IFICS
MDA04-067	Rapid Fabrication of Mirrors
MDA04-068	Optical Sensor for Tracking and Discrimination of Multiple Targets
MDA04-069	Fine Steering Mirrors for Airborne Laser
MDA04-070	Acoustic Mitigation for Airborne Laser
MDA04-071	Innovative Diagnostic Components for Optical System Fault Management
MDA04-072	Lightweight Modular Precision Gimbal Systems
MDA04-073	Advanced Chemical Iodine Lasers
MDA04-074	Chemical Leak Sensors
MDA04-075	Development of novel high bandwidth beam steering mirrors
MDA04-076	Accelerator for Hydrogen Peroxide Cat Bed Start
MDA04-077	Advanced 10 Kelvin Cryogenic Cooling Component Technology
MDA04-078	Manufacturability, Producibility, and Reliability of Space Cryogenic Cooling Technology
MDA04-079	Dynamic Spectral Filtering Techniques
MDA04-080	Radiation-Hardened Multijunction Solar Cells
MDA04-081	New Concepts for Space Infrared Cryogenic Detector Multiplexers
MDA04-082	Superlattice Materials for Very Long Wavelength Infrared Detectors
MDA04-083	Materials and Processes for Bulk Antimony-based Substrate Materials
MDA04-084	Flywheel Attitude Control, Energy Transmission & Storage (FACETS) Technologies
MDA04-085	Long Life Gimbal/Bearing System
MDA04-086	Low-Cost Manufacture of Lightweight Mirror Systems
MDA04-087	High Efficiency Flexible Dye-Sensitized Solar Cell for Space Application

MDA 04.1 Topic Descriptions

MDA04-001 TITLE: Lightweight Energy Production and Storage for High Altitude Airships (HAA)

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: BMDS - MDA/AS (Advanced Systems)

OBJECTIVE: Develop improved lightweight, high energy density, energy production and storage technologies for primary or supplemental power systems in high altitude airships (HAA).

DESCRIPTION: Higher performance and lighter weight energy production and storage technologies are needed to supplement or serve as the primary power systems for HAAs in order to sustain long-term flights. Desirable technologies will be able to support HAA station keeping and operation at greater than 65,000 feet above MSL for one continuous year or more. Environmental factors encountered at an altitude of greater than 65,000 ft. must be considered when developing energy storage. Candidate technologies would likely support nighttime operations (up to 16 hours, cycled one time per day), with power drawn during daytime hours from photovoltaic solar cells or other energy sources. A host of technologies, including, but not limited to, rechargeable battery arrays and lightweight, very high efficiency engines are of interest. Components must accommodate high current draw and require no maintenance for long periods of continuous operation and daily cycling. New technologies and improvements to existing technologies (e.g. life-expanding or performance-enhancing technologies for existing designs) will be considered. Fuel cell technologies will not be considered under this topic heading.

Development Goal:
- Storage = 10kw/kg
- No maintenance operation greater than 1 year
- Reliability of greater than 90%
- Life expectancy greater than 5 years cycling one time per day

PHASE I: Conduct feasibility studies, technical analysis and simulation, or small-scale proof-of-concept studies, according to proposed innovations and improvements. Throughput, life-cycle response, temperature response, and other performance properties should be considered and measured, where applicable.

PHASE II: Implement technology assessed in Phase I effort. Phase II effort should include demonstration of power storage capabilities, combination of components to provide additional power, and integration with power systems with high current draw and cycling characteristics similar to those required to sustain a HAA for several hours. Full testing and verification of performance properties should be included.

PHASE III: The contractor shall finalize the technology of the lightweight energy storage and begin commercialization of the product.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would advance energy production and storage technologies, with application in a spectrum of areas, in both the government and private sectors.

REFERENCES:
1. Khoury, A. and J. David Gillett, ed., Airship Technology, The Airship Association, Cambridge University Press, New York (1999).
2. http://www.acq.osd.mil/bmdo/barbb/haaactd.htm

KEYWORDS: energy storage, energy production, rechargeable battery, high altitude airship

MDA04-002 TITLE: Weight-Reduced Regenerative Fuel Cell Solutions for High Altitude Airships (HAA)

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: BMDS - MDA/AS (Advanced Systems)

OBJECTIVE: Develop improved lightweight, higher efficiency fuel cell technologies as renewable energy systems to supplement primary power systems in high altitude airships (HAA).

DESCRIPTION: Higher performance, lighter weight, and long life cycle regenerative fuel cell technologies are needed to supplement primary power systems for HAAs in order to sustain long-term flights. Desirable technologies will be able to support HAA stationkeeping and operation at greater than 65,000 feet above MSL for one continuous year or more. Environmental factors encountered at an altitude of greater than 65,000 ft. must be considered when developing energy storage. Candidate technologies will likely support nighttime operations (up to 16 hours, cycled one time per day), with power drawn during daytime hours from photovoltaics or other energy sources. Components must accommodate high current draw and require no maintenance for long periods of continuous operation and daily cycling. New technologies and improvements to existing technologies (e.g. life-expanding or performance-enhancing technologies for existing fuel cell technology solutions) will be considered.

PHASE I: Conduct feasibility studies, technical analysis and simulation, or small-scale proof-of-concept studies, according to proposed innovations and improvements. Studies of weight, throughput, life-cycle response, temperature response, and other performance properties should be considered and measured, where applicable, in the context of the operating environment at greater than 65,000 feet.

PHASE II: Implement technology assessed in Phase I effort. Phase II effort should include demonstration of power storage capabilities, high efficiency regenerative implementation, and testing with power systems with high current draw and cycling characteristics similar to those required to sustain a HAA for several hours. Full testing and verification of performance properties should be included.

PHASE III: The contractor shall finalize the technology of the regenerable fuel cell system and begin commercialization of the product.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would advance energy production and storage technologies, with application in a spectrum of areas, in both the government and private sectors.

REFERENCES:
1. R.J. Friedland and A.J. Speranza, "Hydrogen Production through Electrolysis", 2001 Proceedings of the U.S. DOE Hydrogen Program, http://www.eren.doe.gov/hydrogen/docs
2. http://www.acq.osd.mil/bmdo/barbb/haaactd.htm

KEYWORDS: hydrogen generator, electrolyzer, fuel cell, high altitude airship, regenerable power, energy storage

MDA04-003 TITLE: Thin Film, Flexible Photovoltaic Arrays for High Altitude Airships (HAA)

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: BMDS - MDA/AS (Advanced Systems)

OBJECTIVE: Develop improved very lightweight, high efficiency photovoltaic (PV) arrays for High Altitude Airships (HAAs).

DESCRIPTION: Very lightweight, high efficiency, flexible, and durable photovoltaic (PV) arrays are needed to generate electric power for HAAs at greater than 65,000 ft. above MSL. Desirable technologies will likely include thin-film photovoltaics on very light substrates. Desirable technological innovations relate to improving current thin-film solar cell efficiencies and capabilities for making arrays that have low weight, high efficiency, mechanical robustness, low photo-degradation, exhibit excellent performance in the low pressure, high ozone, environment at greater than 65,000 feet, are flexible, and are resilient in environments of fluctuating temperatures. Also crucial are the capability for producing and integrating PVs and substrates in large quantities with low defect rates; potential for lowering costs; and physical, thermal, and electrical compatibility with airship skin materials. Innovations and improvements in any stage of the development/production cycle will be considered.

PHASE I: Conduct feasibility studies, trade studies, small-scale materials proof-of-concept studies, or assess manufacturing enhancement potential at incremental levels, according to proposed innovations and improvements. Weight, throughput, photo-degradation properties, temperature response, and other performance properties should be considered and measured, where applicable.

PHASE II: Validate and expand results found in Phase I efforts. Full testing of properties listed above should be included. The concept should be evaluated to ensure that the performance characteristics are compatible with the mission requirements of the HAA. Demonstration of the potential improvements should be included in the effort.

PHASE III: The contractor shall finalize PV array improvements and begin commercialization of the product.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology has a great deal of potential for applications that could benefit from lighter, more efficient PV arrays, in both the government and private sectors.

REFERENCES:
1. Stand-Alone Photovoltaic Systems: Handbook of Recommended Design Practices, Sandia National Laboratory, Document No. SAND87-7023, available from National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161, 1991 (revised).
2. Workshop Report from the Thin Film Photovoltaic Symposium: Substrates, Contacts, and Monolithic Integration, S. Hegedus, Salbright, et. al., Thin Film Photovoltaic Symposium at the University of Delaware, May 1, 1997. http://www.udel.edu/iec/pubs/SSHpubs/SSH56.pdf
3. Natl. Renewable Energy Lab., Photovoltaics Program Plan FY 2000-FY2004, National Photovoltaics Program, US Dept. of Energy, Washington, D.C. (January 2000).
4. http://www.acq.osd.mil/bmdo/barbb/haaactd.htm

KEYWORDS: photovoltaic array, solar cells, solar array, thin films, high altitude airship

MDA04-004 TITLE: Propulsion and Propeller Technology for High Altitude Airships (HAA)

TECHNOLOGY AREAS: Air Platform, Materials/Processes

ACQUISITION PROGRAM: BMDS - MDA/AS (Advanced Systems)

OBJECTIVE: Improve existing means for controlling large airship movement in a high altitude, low air density environment.

DESCRIPTION: Efficient, lightweight, propulsion is needed for stationkeeping and point-to-point maneuvering of HAAs at approximately 65,000 ft. Desirable advances include development of very large, very lightweight propellers or alternate efficient, propulsion concepts. Winds at this altitude average near 20-40 knots most of the time. However, significant wind spikes of 100 knots are occasionally observed. A desirable airship propulsion system will require no maintenance for a period of continuous operation over one year, have a mean time between failure of at least one year, and be able to accommodate both cases using the minimum amount of power possible, while keeping the airship on station as accurately as possible. Specific considerations include efficiency, maximum thrust, performance over time, mean time between failure, and number of moving parts. Technological innovations related to new propulsion concepts and propeller fabrication will be considered.

PHASE I: For new propulsion concepts, conduct design analyses and a thorough trade study of available or soon to be available electric propulsion technologies and capabilities, as related to HAA needs, and prepare a report on those findings. The study should enumerate advantages and risks related to performance, efficiency, mean time between failure, potential for future improvement with technology, and other criteria. For propeller concepts, the Phase I effort should include a design and simulation study, along with a materials study, which should also detail improvements over current technologies. The Phase I effort may also include small-scale experimentation and testing of candidate materials and designs, to the degree allowed by time and cost restraints.

PHASE II: The Phase II effort should concentrate on realization of the efforts begun in Phase I. This effort would include implementation of a new propulsion concept or full development and testing of new propeller designs.

PHASE III: The contractor shall finalize technical improvements and begin commercialization of the product.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would benefit commercial platforms using electric propulsion in a low air density environment, such as commercial communications airship platforms.

REFERENCES:
1. Khoury, A. and J. David Gillett, ed., Airship Technology, The Airship Association, Cambridge University Press, New York (1999).
2. AIAA-83-0190, "Design of Optimum Propellers," Adkins, et al.
3. "Calculation of the Propulsive Efficiency for Airships with Stern Thruster," AIAA 14 LTA Tech Convention, July 2001.
4. NASA CR 194455, "Effect of Power System Technology," Anthony Colozza.
5. NASA TM-1998-206637, "Design and Performance Calculations of a Propeller for Very High Altitude Flight," L Danielle Koch.
6. NASA CR-1998-208520, "High Altitude Propeller Design and Analysis Overview," Anthony Colozza.
7. http://www.acq.osd.mil/bmdo/barbb/haaactd.htm

KEYWORDS: propulsion, high altitude airship, propeller

MDA04-005 TITLE: Space Qualifiable Laser Technology

TECHNOLOGY AREAS: Sensors, Weapons

ACQUISITION PROGRAM: BMDS - MDA/AS/SL (Advanced Systems/Space Based Laser)

OBJECTIVE: To develop novel, scalable laser technology components leading to higher power laser-based instruments on space platforms

DESCRIPTION: Technology concepts are sought, which advance 1 kW-class to 100 kW-class high-power space lasers. Applications may, for example, be for lidars and illuminators in MDA and Air Force missions. Technologies of interest might apply to high-power chemical lasers (e.g., medium to high energy hydrogen fluoride overtone laser technology), photolytic or electrical lasers, or high photon density solid-state lasers exhibiting high average power and excellent beam quality. The technologies must be traceable to eventually meeting platform requirements for higher laser power per system mass and per system volume and much deeper magazines. Thus a concept must consider impacts of not only the particular laser device, but also the consequences on electric power and thermal management as well. A concept or component should have significantly better chemical or electrical efficiency, whichever applies, while maintaining good beam quality and minimal jitter.

PHASE I: Develop the new technology, show feasibility and estimate the resulting performance improvement over current systems and performance limits by analysis or conceptual laboratory demonstration. Perform sufficient systems study to estimate size and weight and needs for support (power, cooling, beam cleanup and focusing) for a platform. Address what other technologies must be improved in concert in order to achieve the estimated performance gains. Develop a roadmap and a plan to reduce the highest risks in the technology concept. This plan might include design and fabrication of test articles leading to a subscale feasibility demonstration in Phase II. Present a design concept for the test articles.

PHASE II: Perform more elaborate analyses and/or tests designed to identify performance characteristics, problems and limitations. Conduct detailed design and fabrication of test articles. Where feasible, execute test plan to develop and test breadboards/brassboards to demonstrate the new technology.

PHASE III: This laser technology will have direct applicability to future MDA and Air Force laser programs. Also, the techniques developed would have applicability for weapon systems on any mobile platforms, to space based surveillance applications, and to both civil and military space based environmental missions.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technology developed could be applied to commercial laser systems used for space based environmental imaging and mapping systems.

REFERENCES: 1. "Handbook of Chemical Lasers," ed. By R.W.F. Gross and J.F. Bott, Wiley & Sons, New York, NY, 1976, 744pp. 2. "Gas and Chemical Lasers and Intense Beam Applications III," ed. By Steven J. Davis and Michael C. Heaven, Proceedings of SPIE, Vol. 4631, Bellingham, WA., 2002, 296pp. 3. "Solid State Lasers IX," ed. By Richard Scheps, Proceedings of SPIE, Vol. 3929, Bellingham, WA., 2000, 364 pp. 4. "Solid State Lasers VIII," ed. By Richard Scheps, Proceedings of SPIE, Vol. 3613, Bellingham, WA., 1999, 314 pp. 5. "Advanced High-Power Lasers," ed. By Marek Osinski, Howard T. Powell, Koichi Toyoda, Proceedings of SPIE, Vol. 3889, Bellingham, WA., 2000, 894 pp.

KEYWORDS: Chemical Lasers, Solid State Lasers, Hydrogen Fluoride Lasers, High Power Lasers, High Efficiency Laser, Beam Quality, Space Qualifiable Lasers, Lidar, Ladar, Illuminators.

MDA04-006 TITLE: Development of Micro-Scale Laser Technology

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: BMDS - MDA/AS/SL (Advanced Systems/Space Based Laser)

OBJECTIVE: Develop micro-scale technology to facilitate increased system (power to weight and power to volume) performance of current chemical or solid-state laser systems.

DESCRIPTION: Micro-scale technology, such as that using micro-electrical and mechanical systems (MEMS) fabrication techniques, has demonstrated the ability to increase the performance of combustion driven systems such as rockets and gas turbines. MEMS allows controllable, efficient mixing at microscales and geometries through micro-nozzles and micro-passages that were previously unobtainable. It may offer effective localized solutions for high heat flux thermal management such as that needed for diode laser pump arrays. It also may offer the potential to dramatically improve the power-to-weight and power-to-volume performance of COIL and HF/DF (namely, the HF Overtone) laser systems applicable to airborne or space applications. A key aspect of chemical laser performance is the amount of laser energy that can be produced for a given size laser device, both in terms of device weight and device volume. Micro-scale technology would be used to improve current singlet-delta oxygen generators in COIL and/or combustors in HF/DF lasers and to facilitate the development of high pressure, high mass flow laser medium for COIL and/or HF/DF lasers. The ability to operate at higher pressures can lead in turn to more effective pressure recovery systems for both COIL and HF/DF lasers in airborne or ground test operations.

PHASE I: Conduct engineering parameter trade studies to develop concepts, for example for a laser diode array or for 1-kw COIL and/or HF/DF demonstration experiments. Subscale or prototype design for fabrication would be expected; demonstrations of micro-scale concepts would be desirable.

PHASE II: Build micro-scale experiment hardware and determine improved performance of individual subsystems; if for a laser, combine components for demonstration of laser gain and laser power in the 1-kw class COIL and/or HF/DF systems.

PHASE III: Characterize performance of subsystems, including optimization and reliability studies. Transition either experiment hardware and/or mechanical drawings and engineering studies to government agencies to support build-up of government programs for scaling the demonstrated technology.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Reliable, micro-scale technology-based COIL chemical laser systems with good beam quality could potentially be used in a variety of industrial cutting and welding applications, including ship building, aircraft manufacturing, and nuclear-reactor decontamination and decommissioning. Improved heat transfer devices for localized cooling have a huge potential for generic application in the electronics industry.

REFERENCES: 1. Khanna, R., Surface and Coatings Technology, 163-164, pp. 273-280, Jan. 30, 2003. 2. Spadaccini, C.M., Sensors and Actuators A: Physical, 103, Issue: 1-2, pp. 219-224, Jan. 15, 2003. 3. Yang, W.M., Applied Thermal Engineering, 22, Issue: 16, pp. 1777-1787, Nov. 2002. 4. Chau, J.L.H., Chemical Engineering Journal, 88, Issue: 1-3, pp. 187-200, Sep. 28, 2002, 5. Muller, M.O., Bernal, L.P., Washabaugh, P.D., Chou, T-K, and Najafi, K. 40th AIAA Aerospace Sciences Meeting, 2002-0974, Jan. 2002.

KEYWORDS: chemical laser, MEMS, micro-scale, COIL, HF/DF, iodine laser, hydrogen fluoride laser, micro-machining, micro-fabrication, diffusion bonding, micro-rocket, micro-turbine.

MDA04-007 TITLE: <u>Method for Generating a Corrected Beacon Using Non-linear Optics</u>

TECHNOLOGY AREAS: Electronics, Space Platforms

ACQUISITION PROGRAM: BMDS - MDA/AS/SL (Advanced Systems/Space Based Laser)

OBJECTIVES: Develop a non-linear optical correction system to generate a corrected beacon for use in space.

DESCRIPTION: For Space Based Lasers (SBL) and Airborne Lasers (ABL), a major goal is the optimized delivery of energy onto a target at minimum system design weight and cost or complexity. In the propagation of a laser beam to a target, a corrected beam that accounts for the effects of aberration from either turbulence effects or figure error on large optics is desired. To achieve that goal, information impressed onto scattered light from a corrected beacon is used to provide the desired correction. The goal of this call is to develop a method of generating a corrected beacon using non-linear optical methods for a space-based laser system. It is assumed that an uncorrected coherent beam is first used to illuminate the target to initiate the process for the generation of the corrected beacon. With amplification and clean-up of this return, the corrected beacon is generated. Desired attributes for the corrected beacon generation that may pose challenges include the ability to detect and conjugate weak signals approaching 10 photons per resolution element at the “detector” with short lag times approaching tens of microseconds, compensation of point ahead angle from distant targets, a technique to differentiate or separate the target phase information from aberrations of the optical path if needed, compensation of target jitter, and a method to amplify the weak returns to a minimum of a Joule-level, corrected-beacon beam pulse. The offerer should propose a specific non-linear technique(s) to meet the desired attributes, identify specific issues associated with the approach, and how they will be addressed.

Conventional methods of achieving a corrected beacon employs deformable mirrors, wavefront sensors, and extensive reconstruction leading to performance limitations of spatial frequency and temporal bandwidths which can degrade performance and whose solutions are more costly to implement. The State of the Art for Deformable Mirrors (DMs) is approximately 6 KHz, with stroke limits up to 10 microns, and spatial frequencies of 32x32 pixels. In contrast non-linear optics using four wave mixing have reported temporal bandwidths to 100 MHz , stroke capability to 0.1 of the coherence length, and spatial bandwidths of up to 300x300 pixels, all of which are improvements by one or more orders of magnitude. Moreover in some applications severe intensity fluctuations caused by strong turbulence such as thermal blooming will lead to a lack of information for reconstruction and to instabilities in conventional control system. Non-linear optics employing full field conjugation as opposed to DM which provide phase only correction are immune to such difficulties for these strong scintillations. For the case of severe aberrations, for example, arising from aircraft boundary layers, nonlinear optical methods may enable a much simplified, robust control systems in future systems at significantly reduced cost and risk. Advanced systems using large optics operating at increased range or strong turbulence, large stroke, and high spatial and temporal bandwidths pose challenges in cost and performance that only non-linear optics and the use of a corrected beacon to provide viable solutions.

PHASE I: Develop a conceptual design for a nonlinear optical system for generating a corrected beacon for Space (1-6 m primary) application. A feasibility demonstration of key features shall be defined with supporting analysis of correction capability as a function of temporal and spatial bandwidths and phase error. If possible, the collection of supporting data is encouraged using proof-of-concept prototypes.

PHASE II: Develop subscale experiments to validate an approach for scaling to large primary aperture, larger phase errors and higher spatial bandwidths arising from optics and static figure, slow thermal, and dynamic vibration effects in the propagation path. The experiments shall be performed to collect data that will be used to validate that a corrected beacon is generated and its limitations. A design of a corrected beacon system shall be built and demonstrated.

PHASE III: Transition to larger scale testing is intended to result in a validated engineering design and demonstration relevant to physical scale size of a Space-Based Laser system. Other potential commercial uses include improving link margin for low power laser communications, air born applications, lowering the cost and complexity of astronomical laser guide star systems, and improvements to remote sensing systems that emphasizes corrected imaging.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Other potential commercial uses for a corrected beacon include improving link margin for low power laser communications, air born or tactical laser applications, lowering the cost and complexity of astronomical laser guide star systems, and improvements to remote sensing systems that emphasizes corrected imaging.

REFERENCES:
1. T. R. O'Meara, D. M. Pepper and J. O. White,"Application of Nonlinear Optical Phase Conjugation" in Optical Phase Conjugation, edited by R. A. Fisher, Academic Press, 1983
3. E. L. Bubis, O. V. Kulagin, G. A Pasmanik, and A. A. Shilov, "Possibilities for correcting aberrations of imaging laser systems by phase conjugation," Appl. Optics 33, 5571(1994)
4. A.A. Leshchev, V. G. Sidorovich, M. V. Vasilev, V. Y. Venediktov, and G. A. Pasmanik, "Nonreciprocal optical systems with phase-conjugating mirrors-a new class of optical imaging system," Internat. J. Nonlinear Opt. Phys. 3, 89(1994).
5. T. R. O'Meara, "Compensation of laser amplifier trains with nonlinear conjugation techniques", Opt. Eng. 21, 243(1982).

KEYWORDS: Target loop correction of images, non-reciprocal phase conjugation

MDA04-008 TITLE: Advanced Guidance, Navigation and Control (GNC) Algorithm Development to Enhance the Lethality of Interceptors against Maneuvering Targets

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: BMDS - MDA/AS (Advanced Systems)

OBJECTIVE: Develop and demonstrate advanced GNC algorithms (estimators, guidance laws, controllers) for kinetic kill interceptors against advanced maneuvering threats. The advanced GNC algorithms will substantially increase the intercept accuracy of highly maneuvering targets while minimizing the interceptor divert acceleration and divert velocity requirements.

DESCRIPTION: The theoretical basis for current GNC algorithms implement into interceptors have evolved from linear optimal control theory, which includes simple target maneuvers. These implementations suffer from luck of robustness when future threat target maneuvers are encountered since the interceptor to target maneuver advantage required will exceed the maximums achievable. The spiraling and chaotic nature of ballistic targets in the atmosphere will also stress current GNC capabilities to derive and execute a maneuver fast enough and accurately enough to effect a direct hit.

Advanced GNC algorithm development is essential and is needed for meeting lethality requirements against future advanced maneuvering threats, and also for defining future interceptor concepts and associated critical enabling technologies.

PHASE I: Develop robust interceptor GNC algorithms (to include controllers, estimators, guidance laws) that will provide a higher probability of kill against highly maneuvering threats. Performance goals include the minimization of the intercept-to-target maneuver, miss distance and reliance on prior data.

PHASE II: Optimize results of Phase I, evaluate and mature algorithms developed in Phase I in a 6-DOF test bed, and validate the algorithms in real time hardware in the loop facility.

PHASE III: The G&C algorithms developed under the Phase II effort will be implemented and directly inserted into the theater missile defense systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Advanced non-linear GNC algorithm development has applications in the commercial airline industry, unmanned aerial vehicles, robotics, rotorcrafts, etc.

REFERENCES:
1. R. Dorf, Modern Control Systems 6th Edition, Addison Wesley, 1992
2. Ben-Asher, Yaseh, Advances in Missile Guidance Theory, AIAA, 1998
3. P. Zarchan, Tactical and Strategic Missile Guidance, 3rd Edition, AIAA, 1997

KEYWORDS: Control Algorithms, Estimation, Guidance, Interceptors, Neural Networks, Optimal Control.

MDA04-009 TITLE: Miniaturized, Low Weight, Low Cost Interceptor Components for the Miniature Kill Vehicle (MKV)

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: BMDS - MDA/AS (Advanced Systems)

OBJECTIVE: The objective of this effort is to develop innovative low weight, low cost interceptor technologies that enable low mass, highly efficient, agile interceptors to defend against current and projected advanced threats.

DESCRIPTION: Miniature interceptors, especially an integrated version of them launched from a single booster that could intercept multiple objects, have the potential to solve many difficult countermeasure problems, such as antisimulation, submunitions, encapsulated reentry vehicles (RVs) etc. In order to accomplish this, miniature interceptors weighing less than 2.0 kilograms and costing less than $50K are desired. A host of innovative miniature technologies are needed to enable this new paradigm. These technologies include highly efficient structures(<0.3 gr/cc), miniaturized power sources with energy densities (>30 W sec/gram), miniature propulsion systems with divert velocity>500m/sec and very low impulse variation, light weight optics, high data rate MEMS inertial measurement units, reactive material structures for lethality enhancement, innovative fabrication techniques, etc. These technologies can be applied not only to the system referenced above but they can also be integrated into current missile systems and their upgrades.

PHASE I: The objective of this Phase is to demonstrate proof-of-principal of the proposed concepts and technologies towards meeting the performance requirements of a miniature interceptor. These requirements include a weight of <2.0 kilograms, cost <$50K, divert velocity better than 500m/sec, time constant of a few millisecond, high mass fraction and acquisition range >60km. Offerors will verify their proposed concepts and technologies through computer simulations and limited laboratory testing.

PHASE II: Demonstrate feasibility and engineering scale-up of proposed technology. Fabricate a prototype that demonstrates capabilities defined during Phase I and demonstrate the technology in a laboratory environment and finally with field tests.

PHASE III: The developed technology has direct insertion potential into missile defense systems such as the Miniature Kill Vehicle system, THAAD, EKV etc.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technologies developed under this SBIR topic would have applicability to automobile industry such as air bag initiators, brake sensors etc., to the airline industry such as IMU technology, lightweight materials etc., space vehicles.

REFERENCES:
1. Paschal N., Strickland B., Lianos D., " Miniature Kill Vehicle Program," 11th Annual AIAA/BMDO Technology Conference, Monterey, CA, August 2002.

2. Lianos D., Strickland B., " A midcourse Multiple Kill Vehicle Defense Against Submunitions," 6th Annual AIAA/BMDO Technology Readiness Conference, San Diego, CA, August 1997.

KEYWORDS: interceptor, guidance, sensor, MEMS, power sources.

MDA04-010 TITLE: <u>Boost Phase Plume-to-Hardbody Handover</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS - MDA/AS (Advanced Systems)

OBJECTIVE: Develop algorithms that process seeker sensor information and available off-board information in order to intercept a boosting ballistic missile.
DESCRIPTION: The plume-to-hardbody handover algorithms must be capable of locating the hardbody of an exoatmospheric boosting target within its plume from ranges that are appropriate for a boost phase hit-to-kill (HTK) interceptor. The various target types, transient and anomalous target events, extremely fast closing velocities, and short engagement timelines exacerbate these challenges. Additional considerations include the performance, mass, and power usage of the seeker processor and various candidate sensors. Several options exist for the seeker sensor / sensors including single-band IR, dual-band IR, ultra-violet (UV) / visible, and ladar. However, target signature phenomenology is not sufficiently understood at this time to allow for algorithm development for all of these options. The target signature phenomenology in the infrared is fairly well understood and models exist to allow for development of algorithms based on these sensors. Also, due to the target's acceleration during this phase of flight, the range-to-go or relative range rate is needed to perform accurate guidance to the target, making the addition of a ladar sensor an attractive option. The amount of backscatter a ladar sensor will receive from the target's rocket plume that needs to be investigated.

PHASE I: The IR algorithm development needs to ensure algorithm robustness against various targets, target events (staging, chuffing, large angle of attack, etc.), and backgrounds. The algorithms will be properly coded and documented in preparation for submission to the test team for formal testing.

PHASE II: Update algorithms based on Phase I results and demonstrate these algorithms in a realistic environment using actual sensor data. Demonstrate the ability of algorithms to work real-time in stressing environments.

PHASE III: Integrate algorithms into BMD systems and demonstrate the total capability of the updated system. Partnership with traditional DOD prime contractors will be pursued since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERICAL POTENTIAL: Physics-based discrimination algorithms have applicability in robotics, earth science, transportation, law enforcement, medicine, and industrial production.

REFERENCES:
1. Acetta, J.S. and Schumaker, D.L., Ed., The Infrared and Electro-Optical Systems Handbook, Vol. 1-8, SPIE Press, 1993.
2. Jelalian, A.V., Laser Radar Systems, Artech, MA, 1992.

KEYWORDS: Algorithm; Target Discrimination; Rocket Plumes; IR Signature; Counter-Countermeasure

MDA04-011 TITLE: Data and evidence fusion from multiple independent Decision Theoretic sources: Hybrid Decision Networks

TECHNOLOGY AREAS: Information Systems, Sensors, Battlespace

ACQUISITION PROGRAM: BMDS - MDA/AS (Advanced Systems)

OBJECTIVE: Demonstrate improved discrimination algorithm capabilities through the fusion of multiple, independent evidential sources to include, but not limited to, Bayesian Networks, Bayesian Likelihood Ratio Test evidence, Principle Component Analysis, and Multivariate (Joint) Subspace Detection.

DESCRIPTION: Survey existing classifier and discriminator technology as well as data & sensor fusion technologies. Identify each discriminator's required inputs and sensors, constraints, and scenarios of robust performance. Develop feasible fusion schemes which capitalize on and exploit each technologies' strengths and as well as complement any weaknesses.

PHASE I: Develop methodologies and show feasibility (and computability) by analytic or other means. Define limits of applicability for both theoretical and computational reasons.

PHASE II: Develop a prototype implementation of fusion of stated Decision Theoretic Technology utilizing the candidate techniques and methodologies outlined in Phase I. Consider computational performance as well as efficacy. Test and evaluate the technique(s) using progressively more complex cases, including boundary cases, stressing cases and cases beyond the anticipated limits. Characterize computational and efficacy degradation near and beyond algorithm boundaries.

PHASE III: This SBIR would have direct applicability to future MDA BMC2 programs. This fusion scheme would enhance existing MDA algorithms and technology in the area of Decision Theory, research and development.

PRIVATE SECTOR COMMERICAL POTENTIAL: Data and evidence fusion would have commercial application in robotics, transportation, medicine, law enforcement and emergency management.

REFERENCES: Joint Hyperspectral Subspace Detection derived from a Bayesian Likelihood Ratio Test, A. Schaum, Naval Research Laboratory, 2002.

KEYWORDS: Bayesian, Generalized Likelihood Ratio, Likelihood, Principal Component Analysis, Target Subspace Classification, Joint Subspace Detection, Classifier, Discrimination, Optimization, Objective Function.

MDA04-012 TITLE: Generalized Multivariate Decision Theory: Hyperspectral Target Detection in Remote Sensing Operations

TECHNOLOGY AREAS: Information Systems, Sensors, Battlespace

ACQUISITION PROGRAM: BMDS - MDA/AS (Advanced Systems)

OBJECTIVE: Develop new and innovative Decision-Theoretic enabling technologies to support the next-generation MDA BMC2 architecture.

DESCRIPTION: Apply Principle Component Analysis and/or other subspace classifiers, utilize Bayesian Likelihood Ratios in Joint Subspace Detection in the MDA/AS context of remote sensing and monitoring of evolving threat scenarios. Generate Multivariate background and target statistics; define family of decision surfaces to distinguish between background space (clutter characterization), target features (subspace), and noise.

PHASE I: Develop methodologies and show feasibility (and computability) by analytic or other means. Define limits of applicability for both theoretical and computational reasons.

PHASE II: Develop a prototype implementation of algorithms utilizing the candidate techniques. Consider computational performance as well as efficacy. Test and evaluate the technique(s) using progressively more complex cases, including boundary cases, stressing cases and cases beyond the anticipated limits. Characterize computational and efficacy degradation near and beyond algorithm boundaries.

PHASE III: This SBIR would have direct applicability to future MDA BMC2 programs. Also, the techniques developed would have applicability for decision making systems that work with uncertainty in other areas such as ground vehicle survivability (perception models), and many other applications involving feature extraction in clutter scenarios.

PRIVATE SECTOR COMMERICAL POTENTIAL: This technology would have application in medicine, transportation, and law enforcement being able to distinguish between clutter, target features and noise.

REFERENCES: Joint Hyperspectral Subspace Detection derived from a Bayesian Likelihood Ratio Test, A. Schaum, Naval Research Laboratory, 2002.

KEYWORDS: Bayesian, Generalized Likelihood Ratio, Likelihood, Principal Component Analysis, Target Subspace Separation, Target Subspace Classification, Target Subspace Boundary Generation, Joint Subspace Detection, Classifier, Discrimination, Optimization, Pruning, Objective Function.

MDA04-013 TITLE: Laser Radar Algorithms

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS - MDA/AS (Advanced Systems)

OBJECTIVE: Develop algorithms that process passive interceptor seeker information and laser radar information in order to intercept the lethal object within a ballistic missile threat train.

DESCRIPTION: Advanced seeker capabilities against off nominal threats and countermeasures involve the use of active laser radar (ladar) technologies. These include both non-coherent angle-angle-range ladars and coherent ladars that provide range and Doppler measurements. The use of these sensors on-board the interceptor requires the development of robust algorithms to fully take advantage of the ladar seeker's capabilities for enhanced acquisition, discrimination and aimpoint selection. The objective is to develop ladar algorithms that enable enhanced seeker decision functions. These include active/passive fusion algorithms for far range ladar cuing and target acquisition; 3-D metric target object map algorithms for enhanced handover; shape features, microdynamics, and ladar imaging for enhanced discrimination of balloons and decoys; and 3-D angle-angle-range aimpoint selection algorithms for mitigation of endgame countermeasures. Methods for fusing ladar seeker information with target information obtained from passive seekers should be considered for improved discrimination. The development of these ladar algorithms will involve evaluation of the impact of diffuse scattering and laser speckle and the incorporation of robust methods for mitigating these effects.

PHASE I: The IR/ladar algorithm development needs to ensure algorithm robustness against various targets, target events, and backgrounds. The algorithms will be properly coded and documented in preparation for submission to the test team for formal testing.

PHASE II: Update algorithms based on Phase I results and demonstrate these algorithms in a realistic environment using actual sensor data. Demonstrate the ability of algorithms to work real-time in stressing environments.

PHASE III: Integrate algorithms into BMD systems and demonstrate the total capability of the updated system. Partnership with traditional DOD prime contractors will be pursued since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERICAL POTENTIAL: Physics-based discrimination algorithms have applicability in robotics, earth science, transportation, law enforcement, medicine, and industrial production.

REFERENCES:
1. Acetta, J.S. and Schumaker, D.L., Ed., The Infrared and Electro-Optical Systems Handbook, Vol. 1-8, SPIE Press, 1993.
2. Jelalian, A.V., Laser Radar Systems, Artech, MA, 1992.

KEYWORDS: Algorithm; Target Discrimination; Rocket Plumes; IR Signature; Counter-Countermeasure

MDA04-014 TITLE: Electro-Optical/Infrared Multi-frame Processing

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS - MDA/AS (Advanced Systems)

OBJECTIVE: Develop multi-frame processing algorithms in order to intercept the lethal object within a ballistic missile threat train.

DESCRIPTION: The kill vehicle (KV) may use multi-frame data in the form of summed sensor frames to enhance target acquisition range. The process of summing sensor frame data affects the ability to estimate target intensity data from the summed frame, for example, due to effects of frame mis-registration or uncompensated target motion. The KV algorithms for estimating target intensity from single frames must be modified or re-defined to estimate intensity from summed frames. Existing algorithms will degrade with multi- frame summed data.

PHASE I: The algorithm development needs to ensure algorithm robustness against various targets, target events, and backgrounds. The algorithms will be properly coded and documented in preparation for submission to the test team for formal testing.

PHASE II: Update algorithms based on Phase I results and demonstrate these algorithms in a realistic environment using actual sensor data. Demonstrate the ability of algorithms to work real-time in stressing environments.

PHASE III: Integrate algorithms into BMD systems and demonstrate the total capability of the updated system. Partnership with traditional DOD prime contractors will be pursued since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERICAL POTENTIAL: Physics-based discrimination algorithms have applicability in robotics, earth science, transportation, law enforcement, medicine, and industrial production.

REFERENCES:
1. Acetta, J.S. and Schumaker, D.L., Ed., The Infrared and Electro-Optical Systems Handbook, Vol. 1-8, SPIE Press, 1993.
2. Jelalian, A.V., Laser Radar Systems, Artech, MA, 1992.

KEYWORDS: Algorithm; Target Discrimination; IR Signature; Counter-Countermeasure

MDA04-015 TITLE: Super Resolution

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS - MDA/AS (Advanced Systems)

OBJECTIVE: Develop super resolution algorithms in order to intercept the lethal object within a ballistic missile threat train.

DESCRIPTION: Super resolution algorithms will be investigated for dealing with closely spaced objects (CSOs) as seen by the kill vehicle (KV). Two approaches will be investigated. First, algorithms for detecting a CSO condition and making inferences on it without actual decovolution of the intensity data will be investigated. For example, Fourier analyses of the CSO signature. Secondly, several techniques for resolving the intensities of closely spaced objects viewed by an EO sensor have been proposed in the literature under the general heading of "deconvolution" algorithms. Many require a priori knowledge of the number of objects that are closely spaced. This information could be provided by a ladar or by KV-to-KV communication and data fusion. Discrimination is key to the performance of the BMD system and current discrimination algorithms require the sensors to provide spatially resolved track time and amplitude estimates to effect discrimination.

PHASE I: The algorithm development needs to ensure algorithm robustness against various targets, target events, and backgrounds. The algorithms will be properly coded and documented in preparation for submission to the test team for formal testing.

PHASE II: Update algorithms based on Phase I results and demonstrate these algorithms in a realistic environment using actual sensor data. Demonstrate the ability of algorithms to work real-time in stressing environments.

PHASE III: Integrate algorithms into BMD systems and demonstrate the total capability of the updated system. Partnership with traditional DOD prime contractors will be pursued since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERICAL POTENTIAL: Physics-based discrimination algorithms have applicability in robotics, earth science, transportation, law enforcement, medicine, and industrial production.

REFERENCES:
1. Acetta, J.S. and Schumaker, D.L., Ed., The Infrared and Electro-Optical Systems Handbook, Vol. 1-8, SPIE Press, 1993.
2. Jelalian, A.V., Laser Radar Systems, Artech, MA, 1992.

KEYWORDS: Algorithm; Target Discrimination; IR Signature; Counter-Countermeasure

MDA04-016 TITLE: Advanced Discrimination Technologies and Concepts

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: BMDS - MDA/AS (Advanced Systems)

OBJECTIVE: The objective of this research and development effort is to develop advanced discrimination concepts and technologies to induce or enhance discrimination features in the threats of the future.

DESCRIPTION: There is a need for advanced discrimination concepts and technologies to sort through the large numbers of threat like objects anticipated with advanced countermeasure threats. , These countermeasures may be spread over large areas or in the vicinity of suspected lethal objects and must be intercepted or correctly interrogated in order to create a highly reliable defense. MDA is looking for ways to provide greater interceptor kill probability against the advanced threats such as high traffic and penetration aids, anti-simulation threats, etc. This project involves the technology necessary to develop improved midcourse sensors and weapons ability to discriminate lethal objects from other associated objects. The BMDS could dramatically improved with the Advanced Discrimination techniques and Counter Counter Measure capabilities developed under this program. Additional rationale is provided under separate cover.

PHASE I: Conduct experimental and analytical efforts to demonstrate proof-of-principle of the proposed technology and concepts.

PHASE II: Demonstrate feasibility and engineering scale-up of proposed technology; identify and address technological hurdles. Demonstrate applicability to both selected military and commercial applications.

PHASE III: The developed technology has direct insertion potential into the BMDS midcourse elements.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would have applicability to commercial space platforms, high altitude communication platforms, etc.

REFERENCES :
1. Joseph Z. Ben-Asher,Isaac Yaesh, "Advances in Missile Guidance Theory" Volume 180, Progress in Astronautics and Aeronautics, 1998.

2. J.S. Przemieniecki, "Critical Technologies for National Defense" , AIAA Education Series, 1991.

KEYWORDS: discrimination, kill vehicle, counter measures.

MDA04-17 TITLE: Reactive Materials as Lethality Enhancers

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: BMDS - MDA/AS/PEO/Lower Tier (Advanced Systems)

OBJECTIVE: The objective of this effort is to develop technologies in reactive materials and the processes used to produce them. Emphasis will be placed on reactive materials that would achieve high reaction temperatures(>4000K) and generate high amounts of chemical energy(>2kcal/gram) and related overpressure on impact; controlled reactivity properties are important, while at the same time these reactive materials must be able to function as structural components (proper strength, ductility, etc.) of interceptors and missiles. Components of interest are bulkheads, sensor housing, heatshields, etc. Cost effective fabrication technologies that are scalable to production will be investigated.

DESCRIPTION: The project will study the incorporation of reactive materials into an interceptor's structure or as an add on attachment to increase the interceptors lethality. The reactive materials will add chemical energy to the kinetic energy of an interceptors increasing the lethality by a factor of 2-10 depending on the target. Limited progress has been made in developing interceptor tailored reactive materials and manufacturing processes. The need exists to develop and test reactive materials with varying densities from 1.5 grams/cm3 to 8grams/cm3 as substitutes for inner plastics, aluminum and steel components, etc. or as a dedicated add on structure to the current or future interceptors. Reactivity control is important and it is dictated by closing velocities and engagement time available; these times should be consistent with intercepts of TBM's and ICBM's as compared to cruise missiles (microseconds vs. milliseconds).

PHASE I: Analyzed, evaluate and conduct feasibility experimentation of the proposed reactive materials including material characterization and fabrication.

PHASE II: Design, fabricate and test prototype-scale device or components under conditions which simulate realistic targets and velocities of interest. Demonstrate applicability to selected military and commercial applications.

PHASE III: The reactive materials will improve the lethality of interceptors with equivalent or lower costs and this would be the result of a successful development. The developed technology has direct insertion potential into missile defense systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technologies developed under this SBIR topic would have applicability to areas such demolition and blasting, fusible links for electrical circuit protection, combustible structures, cutting torches, etc.

REFERENCES: “Advanced Energetics Technology Exchange”, presentations by Industry and Government at Lawrence Livermore National Lab. Sept. 10-12, 2002.

KEYWORDS: Energetic materials, munitions, lethality

MDA04-18 TITLE: Microsatellite Precision Guidance, Navigation, and Control Concepts

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: BMDS - MDA/AS (Advanced Systems)

OBJECTIVE: The objective of this proposed effort is to explore concepts and develop systems of space-qualified guidance, navigation, and control components and systems to enable microsatellites to maintain precise station-keeping and/or execute precision orbital transfer and rendezvous missions.

DESCRIPTION: Missile defense is a vastly complex process involving numerous systems in a variety of configurations. Microsatellites (mass to 100kg) offer the potential to enhance defense in various deployment options. Existing Inertial Navigation Systems (INS) allow a certain level of performance (in terms of geospatial positioning), constraining functionality. The MDA is seeking innovative concepts in precision navigation, and the associated guidance and control systems, to allow for deployments such as, but not limited to, networked constellations, precision station-keeping, orbital maneuvers, and rendezvous with other space objects. This effort would develop creative concepts for the employment of, for example, ultra-precision microelectromechanical systems (MEMS) accelerometers, novel applications of interferometry or GPS, or other components, algorithms, or methods to enhance positioning of microsatellites.

PHASE I: Develop detailed concept design study of precision guidance, navigation, and control techniques, and quantify the expected performance characteristics with analysis, modeling, or hardware.

PHASE II: Build a working prototype of an enhanced precision guidance, navigation, and control system, and demonstrate initial feasibility in a controlled test.

PHASE III: Refine design of the precision guidance, navigation, and control system for a space-qualified microsatellite application, and perform system test and evaluation for launch preparation.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Precision guidance, navigation, and control systems would have application to commercial microsatellites for communications, sensing, and other areas, and could also enhance the performance of other platforms such as aircraft and automobiles, for improved navigation, among other uses.

REFERENCES:
1. Report of the Commission to Assess United States National Security Space Management and Organization, Donald H. Rumsfeld, Chairman, Washington DC, January 11, 2001.
2. Proceedings, 11th Annual AIAA/BMDO Technology Conference, Monterey CA, August 2002.
3. Proceedings, 1st AIAA Responsive Space Conference, Redondo Beach CA, April 2003.

KEYWORDS: Navigation, Guidance, Control Systems, MEMS, GPS, INS, Microsatellites

MDA04-19 TITLE: Precision Propulsion Concepts for Microsatellites

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: BMDS - MDA/AS (Advanced Systems)

OBJECTIVE: Explore innovative concepts and develop systems of space-qualified precision propulsion components and systems to enable microsatellites to maintain precise station-keeping and/or execute precision orbital transfer and rendezvous missions, steer the spacecraft and sensors, and make incremental orbital adjustments.

DESCRIPTION: Microsatellites (mass to 100kg) provide an opportunity to insert sophisticated sensors and processing technologies into orbits of interest. Precision propulsion systems would allow spacecraft to maneuver precisely to attain and maintain exact ephemerae by generating a single 'bit' of impulse. Microthrusters could potentially reduce thruster cost and minimize thruster fuel requirements. A well-designed system could be integral to the microsatellite design, reducing piece parts, and improving reliability. Precision thrusting could reduce the need for motion compensation, and slew a device more quickly. Precision thrusting could enhance pointing for alignment with other vehicles. Precision intersatellite metrology becomes increasingly important with constellations of microsatellites, and refined impulse could potentially permit complex networked systems to be positioned in exact geospatial coordinates to maximize functionality. Various techniques have been conceived and tested to utilize miniscule quantities of propellant in a suitable matrix for controlled burn. Other techniques have utilized ionization processes and selective heating. Precision to a fraction of a wavelength could open microsatellite constellations to interesting possibilities in coherency effects. This proposed effort would attempt to determine the limits of precision impulse control in a configuration suitable for a microsatellite sensor application and explore innovative alternative approaches to fractional impulsing in a design amenable to the manufacturing process.

PHASE I: Develop detailed concept design study of creative precision propulsion techniques, and quantify the expected performance characteristics with analysis, modeling, and/or hardware.

PHASE II: Build a working prototype of an enhanced precision propulsion technique, and demonstrate initial feasibility in a controlled chamber test.

PHASE III: Refine design for a space-qualified microsatellite application, and perform system test and evaluation for launch preparation, with synergy to commercial use.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Precision propulsion systems would have application to commercial microsatellites for communications, sensing, and other areas, and could reduce cost and improve performance in a variety of missions.

REFERENCES:
1. Proceedings, 11th Annual AIAA/BMDO Technology Conference, Monterey CA, August 2002.
2. Proceedings, 1st AIAA Responsive Space Conference, Redondo Beach CA, April 2003.
3. Report of the Commission to Assess United States National Security Space Management and Organization, Donald H. Rumsfeld, Chairman, January 11, 2001.
4. www.caltech.edu, Digital Micro-Propulsion Project.
5. J.E. Foster, Review of Scientific Instruments, 73, 2020, 2002
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KEYWORDS: Propulsion, Micro-propulsion, Thrusters, MEMS, Control Systems, Microsatellites

MDA04-20 TITLE: Innovative Techniques for Missile Defense

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: BMDS - MDA/AS (Advanced Systems)

OBJECTIVE: Develop innovative concepts for performing the missile defense mission. MDA increasingly depends on advanced technology developments, of all kinds, to invigorate its ability to find and disable missiles in flight and to defend against an increasingly sophisticated threat, to include cruise missiles. Therefore, the continued availability of emerging technology has become a vital part of the MDA mission. MDA has interest in specific technology programs that pursue high-risk technologies that could spur a revolutionary leap or enhancements. Specific goals include, but are not limited to, quickening the pace of technology and innovation developments and decreasing the time required to transform scientific breakthroughs into actual applications. Research or Research and Development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been fully established.

DESCRIPTION: The ballistic missile threat continues to evolve. The Missile Defense Agency is developing a flexible architecture to counter the ballistic missile threat. This effort would develop a technique to counter ballistic missiles that can be further developed and integrated into the missile defense architecture. Areas of interest include but are not limited to:

- Radar Systems, Cross sections and signatures, Measurements (waveforms, data extraction), Hardware (transmit/receive modules), Signal processing, Data visualization, Data compression, and Image interpretation.
- Lasers and Electro-optical Systems, High energy lasers, Passive IR and optical systems, Ladar systems, Optical signal processing, and Hardware (FPA).
- Mathematics and Computer Science, Algorithms, Artificial intelligence, Software Probability/statistics, and Pattern recognition.
- Electrical Engineering, Digital electronics and signal processing, Machine implementation of algorithms, Analog circuits/rf communications, Computer vision, and Distributed computing.
- Physics and Chemistry, Electrodynamics, Nuclear physics and weapons effects, Infrared and optical signatures, Energy conversion, and Rocket plume analysis.
- Mechanical and Aerospace Engineering, Space systems.
- Missile systems aerodynamics, propulsion, Guidance and control, and reentry physics.
- Materials science.
- Battle Management/Command and Control, Engagement planning, Tactics, intelligence exploitation, and countermeasures.
- Decision theory and modeling.
- Target tracking, classification, identification, and discrimination.
- Sensor fusion.

PHASE I: Develop conceptual software, firmware and hardware designs or modifications to existing software that address problem areas addressed above. Conceptual designs would include, but not be limited to flowcharts, simulations and emulations, timing analyses, GUI designs (where applicable) and narrative descriptions of software operations.

PHASE II: Validate the feasibility of the software by demonstrating its use in the testing and integration of prototype items for MDA element systems, subsystems, or components. Validation would include, but not be limited to, software based system simulations, operation in test-beds, or operation in a demonstration sub-system. A partnership with the current or potential supplier of MDA element systems, subsystems or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

PHASE III: Successfully demonstrate new open/modular, non-proprietary, operating software. Demonstration would include, but not be limited to, demonstration in a real system or operation in a system level test-bed. This demonstration should show near term application to one or more MDA element systems, subsystems or components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Depending on the nature of the prescribed technique, there may be commercial applicability.

REFERENCES: (1). Advanced Concepts Broad Area Announcement dated February 22, 2002 with modifications (Feb 26, 2002, May 31, 2002, August 08, 2002 and October 15, 2002) http://www2.eps.gov/spg/ODA/MDA/WASHDC1/Reference-Number-HQ0006-02-AC-BAA/listing.html

KEYWORDS: missile defense; innovation; threat; advanced; concept; analysis, opportunities

MDA04-21 TITLE: Processing techniques for Multiple Wavelength Infrared Sensors

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: BMDS - MDA/AS (Advanced Systems)

OBJECTIVE: Develop and test signal and image processing algorithms specifically designed to operate with signals from monolithic multiple wavelength infrared detector arrays.

DESCRIPTION: Infrared focal plane arrays (FPAs) that integrated structures for detecting multiple wavebands into a monolithic structure have achieved various stages of technical readiness. These devices can provide images that are spatially and/or temporally registered without additional processing. Correct registration allows joint processing of the measurements in each waveband on a pixel-by-pixel basis that isn't possible when separate FPAs are used for each waveband. New processing techniques may include digital techniques implemented after sampling and digitization or analog techniques implemented on or close to the FPA. New techniques can provide reduced computational demands or improved sensor system performance. Processing techniques may be applicable to detection and tracking of unresolved objects or to the imaging of extended objects.

PHASE I: Design and simulate new processing techniques that are only possible with monolithic multiple wavelength infrared PFAs. Analyze performance and throughput advantages gained from the proposed techniques. Identify and analyze the key challenges in the development of real-time implementation.

PHASE II: Fabricate a prototype that demonstrates capabilities defined during Phase I and demonstrate in a laboratory environment.

PHASE III: Integrate and test processing techniques into sensor subsystems for insertion into air and space sensor platforms and interceptor systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The commercial market for infrared sensors is extensive and performance or processing throughput improvements would impact many applications. Commercial application areas include industrial thermal imaging, law enforcement, public safety, search and rescue, vegetation mapping in agriculture, and quality control monitoring.

REFERENCES: (1). Advanced Concepts Broad Area Announcement dated February 22, 2002 with modifications (Feb 26, 2002, May 31, 2002, August 08, 2002 and October 15, 2002).
http://www2.eps.gov/spg/ODA/MDA/WASHDC1/Reference-Number-HQ0006-02-AC-BAA/listing.html

KEYWORDS: missile defense; sensors

MDA04-22 TITLE: Early Launch Detection, Booster Typing, and Kill Assessment Sensor Concepts

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: BMDS - MDA/AS (Advanced Systems)

OBJECTIVE: Develop and demonstrate high payoff all-weather surveillance and characterization sensor technology for boosting targets to be transitioned to airborne EO/IR sensor systems.

DESCRIPTION: An advantage of a boost phase intercept system is that the target is moving slower, its bright plume offers easier tracking and the boosting missile is more vulnerable. The launch locations can be deep in the adversary's territory, requiring substantial standoff ranges, early detection is critical for successful engagement. Detecting the launch as early as possible is essential to developing a track, determining the type of missile, initiating weapons engagement, and determining engagement success. New and innovative approaches to early launch detection and target characterization are needed. Sensor characteristics include: large standoff range, prompt detection time, all weather (high availability), high probability of detection and low probability of false alarm, and high resolution measurement of spectral, spatial, and temporal signatures. This SBIR addresses the definition, concept development, and demonstration of airborne SWIR and MWIR sensors that support spectral, spatial, and temporal signature measurement.

PHASE I: Phase I SBIR efforts should concentrate on the development of the fundamental sensor concepts that can be integrated into a single airborne platform. This could include demonstration of sensor configurations in a format that illustrates how the technology can be further developed and utilized to detect and characterize boosting targets. This effort should include plans to further develop and exploit the concept in Phase II.

PHASE II: Phase II SBIR efforts should take the concept of Phase I and design/develop a breadboard sensor to demonstrate the concept. The sensor may not be optimized to flight levels but should demonstrate the potential of the working prototype sensor to meet emerging operational requirements. Demonstration of the potential improvements in mass, input power, and performance parameters should be included in the effort.

PHASE III: Potential opportunities for transition of this technology include the commercial sector and military programs that would benefit from improved multiple feature characterization.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Opportunities for developing commercial applications of the technology include remote/environmental sensing, rocket launch detection and characterization by NASA and environmental monitoring agencies.

REFERENCES: (1). Advanced Concepts Broad Area Announcement dated February 22, 2002 with modifications (Feb 26, 2002, May 31, 2002, August 08, 2002 and October 15, 2002).
http://www2.eps.gov/spg/ODA/MDA/WASHDC1/Reference-Number-HQ0006-02-AC-BAA/listing.html

KEYWORDS: missile defense; sensors

MDA04-23 TITLE: Optimized Management of Multiple Networked Sensors

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: BMDS - MDA/TE (Test and Evaluation), MDA/SE (System Engineering)

OBJECTIVE: Develop and test optimized techniques to dynamically manage multiple networked sensors on a single platform.

DESCRIPTION: An increasing number of missile defense systems employ multiple sensors on a single platform to concurrently perform distinct functions. A single platform may either support several sensors with similar employment characteristics (several infrared wavebands) or sensors with different incongruent requirements (passive EO/IR and active ladar). Various missions and operating environments may require dynamic selection of the sensor operating mode, platform attitude, the degree of autonomy, signal processing algorithms, network connections, and data communication format. Several of these functions require feedback from the signal processing algorithms to the sensor management functions.

Mathematical tools are needed to optimize the allocation of resources between co-located sensors and sensors on other platforms in the network while carrying out the competing missions of surveillance, detection, tracking, and discrimination. Optimization tools must recognize the interdependent network of functional elements including sensors, communication resources, processing nodes, and engagement systems while adapting to a variety of threats and environments. Useful tools for optimized sensor management must ensure a minimum level of functionality when faced with threats and environments outside the design optimization space.

PHASE I: Design and simulate new concepts for optimized sensor management that are applicable to multiple sensor platforms that operated in an interdependent network of functional elements. Provide a method to formally specify a configuration of the sensors and network interfaces. Analyze theoretical performance limits of the management technique for specified sensor configurations.

PHASE II: Apply the sensor and network configuration method to sensors on a typical BMDS platform (interceptor, space-based, or airborne). Develop a software prototype that demonstrates the capability to optimize sensor management and/or adaptive processing. Exercise the software model for a range of realistic BMDS scenarios.

PHASE III: Integrate and test sensor management and processing techniques into sensor subsystems for insertion into airborne or interceptor sensor platforms for tests and demonstrations.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The commercial market for integrated multiple sensor platforms is extensive and performance or processing throughput improvements would impact many applications. Commercial application areas include law enforcement, public safety, search and rescue, vegetation mapping in agriculture, and quality control monitoring.

REFERENCES: (1). Advanced Concepts Broad Area Announcement dated February 22, 2002 with modifications (Feb 26, 2002, May 31, 2002, August 08, 2002 and October 15, 2002).
http://www2.eps.gov/spg/ODA/MDA/WASHDC1/Reference-Number-HQ0006-02-AC-BAA/listing.html

KEYWORDS: missile defense; sensors

MDA04-24 TITLE: Improvements in Infrared Scene Projection for Hardware-in-the-Loop (HWIL) Testing

TECHNOLOGY AREAS: Sensors, Space Platforms

ACQUISITION PROGRAM: BMDS - MDA/TE (Test and Evaluation), MDA/SE (System Engineering)

OBJECTIVE: Improve Infrared 2D Scene Projection Component Technology.

DESCRIPTION: Critical performance evaluation of algorithms, optics, and sensors for many defense and commercial applications rely on the ability to generate flickerless infrared movies that precisely approximate typical objects, backgrounds and transient events. The goal of this topic is to pursue the development of the physics and device technology for infrared scene projection supporting development analysis of MDA weapons systems that is beyond the current state-of-the-art. Current projection technology based on resistive arrays, micromirror arrays, computer workstations and motion tables is capable of generating flickerless, broadband scenes, at greater than 512^2 spatial resolution, and high framerates. Limitations include small dynamic range, large power consumption, strict alignment and calibration requirements and limited high frequency motion control. Opportunities exist in the areas of superconducting power distribution backplanes, non-resistive emissive or reflective and frequency-agile source arrays and motion table improvements for high frequencies. Additionally, very high frame-rate (>1000 fps) graphics capabilities are needed.

Solutions to these and other pressing problems in HWIL scene projection technology advancement are sought. For the purpose of defining approaches, the projector should allow testing of a specific sensor having a two-micron bandpass anywhere within the 2-14 micron band. The projection concept should be able to achieve at least a 512^2 spatial resolution, provide a non-temporally-modulated output, and, if pixelated, achieve pixel response times of less than 1.25 millisecond.

PHASE I: Infrared projector concept definition. Identify the physics and new device technology that provides improved or significantly alternate approaches to the current limited state of the art. Perform critical component or technology proof of concept.

PHASE II: Develop prototype Infrared projection "engine" critical components and demonstrate in a prototype projector configuration. Evaluate and document performance capabilities and limitations. Perform critical experiments that define the limits of capability and define a fabrication process path to a core device that can transition to a "production" infrared scene capability.

PHASE III: Refine prototype concepts and transition to MDA major program element contractors and test facilities to provide critical scene generation/projection capability. Either through infrared system test companies or independently define and integrate "core" projector engine into a precision infrared scene projector system. Work with commercial IR imaging systems houses, automatic image recognition algorithm developers, and military tactical IR system houses to integrate technology into automated test, training, and preflight evaluation systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The entire IR sensors and DoD guided weapons community would benefit directly from this development. All weapon programs relying on infrared sensors against high contrast targets would benefit. Commercial products designed for fire fighting or search and rescue could use this product for developmental testing or training. With the advent of real time IR systems for fire fighting, forest fire hotspot location, and driver night vision systems for personnel and commercial vehicles/aircraft IR scene projection technology could easily move into the commercial sector with these developments.

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2. B.E.Cole, et al., "High-Speed large-Area pixels Compatible with 200-Hz Frame rates," Proceedings of SPIE, Vol 4366, Pgs. 121-129, April 2001

3. Shoji, Tanaka, "High-Temperature Superconductivity: History and Outlook ", JSAP No 4, July 2001. http://www.jsapi.jsap.or.jp/Pdf/Number04/PastPresentFuture.pdf

4. M. J. P. Pullin, X. Li, J. D. Heber, D. Gevaux and C. C. Phillips, "Improved efficiency positive and negative luminescence light emitting devices for mid-infrared gas sensing applications", SPIE Proceedings 3938-22, p. 144 (2000).

MDA04-25 TITLE: Visible/UV Image Projector for Sensor Testing

TECHNOLOGY AREAS: Sensors, Space Platforms, Weapons

ACQUISITION PROGRAM: BMDS - MDA/TE (Test and Evaluation), MDA/SE (System Engineering)

OBJECTIVE: Develop an optical image projection technology to provide complex, dynamic stimuli to ultra-violet or visible/near-IR sensors.

DESCRIPTION: Current commercial technology for visible and ultraviolet image projection cannot provide the dynamic range, contrast, spectral range, or image generation rate needed to support critical optics, detector, algorithm, and operational performance of developmental sensors and weapons systems. The capabilities are needed for performance validation of systems in most MDA elements and DoD tactical systems . Guidance, tracking, and navigation systems under development take advantage of signature characteristics of objects in ultra-violet, visible, and near-IR wavebands. Image projection systems are required for laboratory closed-loop testing of the sensors and their associated control and image processing systems. In hardware-in-the-loop tests a scene generation computer produces an image based on the relative position and orientation of the focal plane array sensor and the objects/background being observed. This digital scene data is then transmitted to a calibrated projection system for presentation to the sensor. Past scene projection research has been predominantly focused on the use of Infrared Resistor Arrays to realistically simulate dynamic infrared objects and background at temperatures up to roughly 700 Kelvin. This SBIR topic is focused on the development of technologies that can project images between 200 and 2000 nanometers. Challenges include non-modulated "flickerless" addressing methods to minimize test article interface issues, simultaneous, or extremely rapid "Snapshot" pixel update, scene dynamic range of 14 bits, a rise (0-90%) or fall time (100-10%) of less than 1 millisecond, pixel non-uniformity of less than 1%, and scene formats of 1024x1024 or greater. Approaches involving, but not limited to, conventional and organic light emitting diodes, liquid crystals, phosphors, and MEMs technologies are of interest.

PHASE I: Definition and design/analysis for a visible and/or UV projection concept that meets the above-defined objectives over some or all of the waveband of interest. Identify the physics and new device technology that provides improved or significantly alternate approaches to the current extremely limited state-of-the-art. Perform critical component or technology proof of concept experiment/demonstration.

PHASE II: Develop prototype visible and UV critical "core" component technologies and demonstrate in prototype projector configurations. Evaluate and document approach performance capabilities and limitations. The goal is to demonstrate the capability for the technology to achieve critical performance points including up to 400Hz frame-rate, with an image format of 1280 x1024 or greater. Perform critical experiments that define the limits of capability and define a fabrication process path to a core device that can transition to a "production" infrared scene capability. Establish initial relationships with major projector systems commercial entities to define transition of technology into commercial applications to establish a volume production interest level.

PHASE III: Refine the prototype design and develop and transition the system to many MDA and DOT&E DoD program activities for government and contractor use in system evaluation. Integrate the new technology into commercial projection systems or develop/partner with projection systems commercial sources for transition of technology to create a robust commercial sector supplier of technology for future DoD requirements.

PRIVATE SECTOR COMMERCIAL POTENTIAL: High brightness tactical and commercial displays, spectroscopy sources, photo-therapy sources. The visible projector has the potential to enhance the state-of-the-art of Digital Cinema movie projection systems for the entertainment industry by increasing dynamic range, intensity resolution, and frame-rate. The frame rate and dynamic range envision is needed for development of "beyond-visual-acuity" flight and vehicle training simulators and virtual reality training systems. The technology also has direct potential application in lifetime improvement and performance improvement in lithography, consumer home electronics, professional visualization, and virtual reality entertainment applications.

REFERENCES:
AD Number: ADA355943, Recent Technology Developments for the Kinetic Kill Vehicle Hardware-In- The-Loop Simulator (KHILS), Murrer, Robert L., Jr.; Thompson, Rhoe A.; Coker, Charles F.,Report Date: 1998.

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KEYWORDS: hardware-in-the-loop, scene generation, scene projection, MEMs, Organic LEDs, LCD, Phosphors, UV

MDA04-26 TITLE: Advanced Ladar Signature Modeling Techniques

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: BMDS - MDA/SE (System Engineering), MDA/TE (Test and Evaluation)

OBJECTIVE: To develop and demonstrate new techniques for modeling Ladar signatures of missile plumes, post-boost vehicles, re-entry vehicles and debris. This effort should include the integration of the Ladar plume signature generation with other lidar solid object signature codes into a composite object/plume signature.

DESCRIPTION: The Missile Defense Agency (MDA) is interested in advancing the current state-of-the-art of Ladar signature modeling. Current simulation codes are limited in their fidelity for both military scenes and commercial applications in motion capture and architectural 3D geometry capture of dynamic environments. In particular research is needed for understanding and the correct representation of the complex scattering physics for ladar returns from dynamic plumes represented in missile, aircraft, and engine exhausts. Physics-based models of laser interactions with plumes and debris from hardbody/plume transient events are needed to accurately predict scenes of staging, chuffing, transients, persistence, debris, and countermeasures in support of MDA algorithm development and testing. Ladar sensing (coherent and incoherent) can provide phenomenology features, booster hardbody shape, plume characteristics, estimate of range, and hence time-to-go, needed for endgame homing, and hit-to-kill guidance (plume to hardbody handover and aimpoint selection) against accelerating targets. The Ladar can be configured to measure active polarization signatures as well as range. Active polarization techniques have been proven to penetrate scattering media, such as plumes, better than unpolarized active approaches.

PHASE I: Develop new analytical approaches and physics based investigations to modeling Ladar signatures for debris. Deliver conceptual design of approach.

PHASE II: Develop detailed design and prototype model of Ladar signatures for plumes and debris, including the integration of composite Ladar hardbody and plume composite signatures. Demonstrate that the plume composite signature presents a validated physics based representation of complex scattering phenomena. Demonstrate the ability to execute real time versions of the code for use in sensor performance prediction and integration.

PHASE III: Integration with representative MDA codes such as DELTAS, CHAMP, Real-Time CHAMP, FLITES, SSGM, and BEST to for development and testing of sensors and algorithms in Government, contractor support of MDA and DoD programs. Perform validation of synthetically generated Ladar signatures with real-world measurement data.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The techniques developed could be applied to homeland defense for detection and identification of rogue commercial aircraft (hardbody and plume), commercial pollution monitoring and tracking for smoke stack and dust emission, in forest fire smoke and chemical plume emission/spill tracking and industrial manufacturing pollution perimeter monitoring in accordance with Clean Air Act of 1990 amended 1997. The capability is also needed to predict and model the data returns used to measure and understand high altitude jet aircraft particulate mixing and commercial launch missile plume particulate mixing with the upper atmosphere and impact on global warming and weather.

REFERENCES:
1. Battlespace Environment and Signatures Toolkit (BEST), http://vader.nrl.navy.mil/

2. Synthetic Scene Generation Model Papers, Validation Reports and Presentations, http://vader.nrl.navy.mil/

3. Robert A. Reed, Mitch Nolen, I. Bankman, J. Giles, P. Lang, Marty Venner, Martin Wehling, Martin N. Ross, John Stryjewski, Douglas Brenner, "Plume Active Signatures for Lidar," 2003 Military Sensing Symposium: Missile Defense, Sensors, Environments, and Algorithms, Naval Postgraduate School, Monterey CA, 21-23 Jan 2003.

KEYWORDS: Laser radar, Ladar, plume, debris, CHAMP, Real-Time CHAMP, FLITES, SSGM, BEST, laser Doppler, laser scattering

MDA04-27 TITLE: Advanced PC Scene Generation Techniques & Hardware Architectures

TECHNOLOGY AREAS: Sensors, Weapons

ACQUISITION PROGRAM: BMDS - MDA/SE (System Engineering), MDA/TE (Test and Evaluation)

OBJECTIVE: To develop and demonstrate new and innovative multi-spectral (Ladar, UV, VIS, IR, and Radar) PC scene generation techniques and hardware architectures for simulation, integration, performance evaluation, and testing of weapons and sensors.

DESCRIPTION: The Missile Defense Agency (MDA) is interested in advancing the current state-of-the-art for multi-spectral (Ladar, UV, VIS, IR, and Radar) scene generation techniques to support algorithm development and testing. Scene generation requires accurate simulation of all aspects of the target in boost phase including hardbody, plumes, staging, chuffing, persistence, shroud ejection, maneuvers, and countermeasures. To test the algorithms, the scenes generated need to span all relevant engagement space and include time dependent spatial, temporal, and spectral sampling regimes. Because HWIL tests advanced guidance and control systems, the computations need to be synchronously performed at the sensor rate and represent complex vehicle dynamics. Real time physics-based scene generation of passive sensors is now accomplished through the use of special purpose high-end graphics workstations, which are expensive and rapidly become obsolescent. Current efforts are underway to modify the current generation of complex physics-based scene generation codes to run on externally synchronizable PC based multiprocessor systems. Among the new challenges are PC-based simulation of complex hyperspectral and active Radar/Ladar/SAR wavefront generation/return. Generating these real time volumetric physics-based data sets at very high (100 to 1000 data-cubes per second) "frame" rates represents a quantum increase in computing complexity. Other developments include innovative use of graphics GPU for floating point signal processing and use of re-entrant/recursive digital signal processing cores in the GPU to offload complex waveform calculations and radiometric/electromagnetic calculations off the microprocessor unit. An additional need is for compatible pixel stream combiners/convolvers to convert groups of output pixel streams into time varying intensity, phase, and/or frequency waveforms to inject into sensors or signal processor receivers as the simulated waveforms.

To perform complex volumetric calculations, physics calculations, rendering, and volumetric convolution of waveforms, modular PC processor architectures are needed with tightly coupled graphics/signal processing coprocessors, all synchronized pixel by pixel onboard and cross board.

PHASE I: Demonstrate, using modeling and simulation and/or limited prototype hardware demonstration, the feasibility of new and innovative approaches to any of the problems discussed in this topic related to PC scene generation. Show how new multigraphics processor architecture is supported with COTS products.

PHASE II: Detailed design and development of a prototype multi-spectral (Ladar, UV, VIS, IR, and Radar) PC scene generation system.

PHASE III: Integration with representative MDA HWIL codes such as CHAMP, Real-Time CHAMP, FLITES, SSGM, and BEST to for development and testing of sensors and algorithms in government and contractor research and test facilities. Demonstrate real-time combination of complex temporal waveforms and generation of hyperspectral data-cubes from simultaneous multiple band data sets. Perform validation of synthetically generated scenes/signatures with real-world measurement data.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This project will impact all areas of virtual training and simulation including flight, driving, and ship simulators. This innovation will have impact in all areas of high performance graphics including digital medicine, virtual surgery, mapping, computer aided design, digital cinema, homeland defense for hidden weapon screening and air traffic control. Computational applications such as CFD, weather modeling, molecular biology and complex bio-chemical calculation/visualization could also benefit from this effort. Another application of great potential is to enhance the state-of-the-art of Digital Cinema movie projection systems for the entertainment industry by increasing dynamic range, intensity resolution, and frame-rate.

REFERENCES:
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KEYWORDS: hardware-in-the-loop, seeker testing, real time scene projection, scene generation, HWIL, FLITES, CHAMP, Real-Time CHAMP, SSGM, BEST, physics based models, ladar scene generation, radar scene generation, floating point graphics chip

MDA04-28 TITLE: <u>Realtime Body Dynamic Antenna Modeled GPS/JAMMER Simulator for HWIL</u>

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: BMDS - MDA/TE (Test and Evaluation), MDA/AS (Advanced Systems)

OBJECTIVE: To develop and demonstrate new and innovative technologies for dynamic motion testing systems with inertial sensors and GPS.

DESCRIPTION: Highly dynamic six-degree-of-freedom motion simulation is used to demonstrate advanced guidance and control systems used to for weapons, satellites, vehicles, as well as commercial aviation and vehicle navigation systems. A significant hurdle that must be overcome is to provide closed-loop stimulation to weapon sensors so that they respond as they would during flight. Sensors that are typically tested include missile seekers, inertial measurement sensors, GPS receivers, and data links. Flight motion simulator concepts are being developed that meet requirements for cryogenic testing, simulation of airframe vibration, or address control complexities of hybrid large travel high frequency systems. With the advent of GPS as a position and guidance tool the complex waveforms received from distributed antennas on a small interceptor provide a challenge to simulate. The placements of the antennas provide ample opportunity for phase modulation and multi-path interference during the motion of the vehicle during flight. Large dynamic movement while maneuvering or thrusting is possible with complex variations of 6 degree of freedom motion. To accurately simulate the changes in phase front from many different satellites and noise/jamming sources is a complex problem that should best be dealt with digitally up to the point of signal injection at the antenna port. The problem is to real-time calculate the true convolved intensity and phases of the various signal source received by the vehicle antennas based on the apparent position of the vehicle mounted on the flight table during the fly-out simulation. Once calculated, then to digitally synthesize, convert to RF and inject a true waveform into the antenna ports of the GPS receiver system on a test bench located near the flight table. To fully represent a robust environment up to 12 satellites and 10 "noise" sources should be considered with all current and planned precision codes.

PHASE I: During Phase I, demonstrate technology feasibility through modeling and simulation. Show feasibility of approach and derive a performance prediction through digital simulation and/or limited hardware demonstration.

PHASE II: Develop multi-channel GPS and noise source prototype digital synthesizer concept. Integrate with antenna modeling capability and motion simulator feedback system to provide prototype experimentation and demonstration capability to investigate optimum algorithm and hardware simulation of complex vehicle dynamics in the presence of highly power interference sources. Demonstrate that amplitude and phase information from different types of sources and satellite signals can be accurately combined and economically presented to the system under six degree of freedom motion simulation and evaluation. Perform critical experiments with military and commercial GPS receivers to document range of capability for incorporation into GPS system development and future simulation system development.

PHASE III: Refine the design and develop a system for use in Government and contractor facilities for integration and testing of high mobility GPS navigation and tracking system under severe environments. Work with GPS hardware manufacturers to provide capability to develop new and robust GPS receivers for personal, aviation, and vehicular applications to minimize signal loss in noisy and critical performance applications like landing and emergency vehicle operations.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The private sector will benefit from enhanced capability to test dynamic GPS systems and data links required to operate with high accuracy in extreme dynamic and random signal environments. As more and more broadband network and terrestrial microwave sources intrude near the GPS band, spurious signal degrade the ability of “low-cost” GPS receivers to perform critical navigation and guidance tasks. As the reliance for GPS increases in civil and commercial aviation, emergency response, and container ship/tanker port entry, the susceptibility of these systems to severe degradation is increasing due to increase terrestrial RF noise sources and both deliberate and unintentional jamming from external and own-systems interference. This capability will be useful for full geometry evaluation of receiver and antenna designs to mitigate and compensate for both antenna placement limitations and the use of smart antenna management to minimize external source and co-site interference.

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KEYWORDS: hardware-in-the-loop, GPS testing, GPS real-time simulation, flight motion simulators, scene generation, real time antenna pattern prediction, kinetic energy weapon, HWIL GPS, GPS Jamming

MDA04-29 TITLE: <u>Analog Lightwave and Arbitrary Waveform Components for Ladar Scene Generation</u>

TECHNOLOGY AREAS: Sensors, Space Platforms, Weapons

ACQUISITION PROGRAM: BMDS - MDA/TE, MDA/SE, MDA/AS, MDA/KI

OBJECTIVE: Develop low-cost dynamic scene projector components for HWIL testing of ladar sensors.

DESCRIPTION: Current Hardware in the Loop technology is predominantly focused on use of Infrared Resistor Arrays to realistically simulate high dynamic infrared scenes and backgrounds. New imaging laser radar and RF/MMW sensors are being developed for MDA applications that require a 3D image (data cube) to be projected for each frame. Configurations are expected for up to 512 by 512 channels at 10 to 1000Hz frame-rate. Ladar sensors measure the spatially distributed time delay and intensity or frequency shift associated with a laser pulse reflecting off of background and target objects. An inexpensive approach to representing the dynamically changing return distribution is required to test ladar sensors in hardware-in-the-loop facilities. The “scene” content is generated by computer to drive the ladar scene projector based on the relative geometry between the sensor and the background/target objects. Direct detection angle/angle/range, range resolved Doppler, and Geiger mode configurations are under consideration. Dynamic ranges of over 60dB are required with intensities from 1.5 milliwatt to 1 nanowatt per pixel return. Very linearized optical sources are required with precision programmable delayed response and extremely high extinction ratio. Wavelengths vary depending on application but this demonstration should consider operation from 500 nanometers to 2400 nanometers with 1064 and 1550 nanometers as a goal. In a typical scenario the ladar sensor firing of the laser pulse will trigger the projector. Based on current scene content (ranges, velocities, and intensities) calculated by the external scene generation computer, the ladar scene projector would generate a convolved waveform return pulses into each projector pixel at the appropriate time. Innovative and low cost approaches are required for the optical sources and for the arbitrary waveform synthesizers and control electronics that drive the sources. Concepts for investigation may include either high-speed laser diode arrays or electro-optic modulator arrays (Electro-absorption, Semiconductor Optical Amplifier, polymer Mach-Zehnder, VCSEL, edge emitter or similar devices). The system will be triggered by the prototype ladar sensor under test and project laser signals into the optics of the sensor simulating a real world return including atmosphere, hardbody, plumes, debris, and countermeasures. The eventual goal is a 512 by 512 element array (up 262K channels in a minimal size footprint) to simulate return from ladar sensors. Return pulse timing accuracy on the order of 500 picoseconds is desired. Modulation speeds of up to 2GHz are envisioned. Segmented arbitrary waveform memory with drive electronics is needed to represent multiple per returns per pixel at different ranges. Uniformity corrected intensity resolution of at least 12-bits is desired over the full dynamic range of intensities.

PHASE I: The initial effort will investigate and demonstrate different approaches to fabricate and demonstrate the critical projector system components leading to a minimum 4 optical channel per module light source and or modulator system with arbitrary waveform drive electronics. Objectives are to demonstrate performance, scalability, and integration potential for 256 channels per “card”.

PHASE II: The phase II effort will address integration with different Photonic components and investigate large-scale integration and use of high density packaging technologies. The ultimate goal is a very high-density cross-connected system with 256 channels per card integrated with pulse to pulse programmable arbitrary waveform memory. Demonstration will include sources, modulators, driver integrated with power, control, cooling and individual channel non-uniformity adjustment. The phase II effort should also address interfaces for timing and real-time drive interface electronics using standard PC interfaces.

PHASE III: Develop a integrated projection system with up to 500 kilometers of time accuracy using segmented multi-return waveform memory of memory per channel for government and contractor HWIL test facilities.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Commercial/military applications include threat system simulators for test/training ranges, phased array radar control, 2D digitizing systems, collision avoidance, high-density communications cross-connect switching buffers. Other commercial applications include digital cinema, phased array radar control for air traffic control, and medical imaging.

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KEYWORDS: HWIL, Ladar Projector, Radar Simulator, arbitrary waveform generation, VCSEL driver, semiconductor optical amplifier, polymer fiber modulator, phased array, analog photonics, RF photonics

MDA04-30 TITLE: Novel Infrared Point Sources

TECHNOLOGY AREAS: Sensors, Space Platforms, Weapons

ACQUISITION PROGRAM: BMDS - MDA/TE, MDA/SE, MDA/AS, MDA/KI

OBJECTIVE: Develop novel high-apparent temperature emissive devices, capable of high frequency temperature modulation, to replace existing resistance-heated blackbody cavity sources.

DESCRIPTION: A projection system is required for real-time representation of point target radiances during hardware-in-the-loop testing of infrared and visible missile defense sensors.

To simulate small higher temperature unresolved objects (plumes, flares, fires, etc.) large resistive-element heated, cavity-type, blackbody sources are used. The physical size, weight, and electro-thermal dynamics of these sources lead to numerous challenges in building compact, high dynamic rate simulation projector systems. Urgently needed are miniature broad spectral radiant sources that can represent target temperatures from ambient to 3000 Kelvin. One approach may be to use room-temperature-operated Infrared Light Emitting Diodes/Laser Diodes recently developed to integrate multiple small sources in a common very small component package. Aperture sizes down to 1mm are needed along with sources that can be spectrally tuned by combining sources with overlapping wavelength output. Negative luminescence technologies demonstrated in US, UK and Ukraine should be addressed as a possible means to increase contrast and project apparent temperatures below ambient. Chalcogenide fiber broadband sources pumped with laser diodes are another approach being pursued. Modulation of the source at rates exceeding 1 kHz is needed. Accuracy, repeatability, and stability of the technology over a wide range of operating environments are important factors in selecting candidate technologies. The ability to couple to infrared fibers for remote and high source motion rates is desirable.

PHASE I: Develop and demonstrate miniature IR point sources with output from 2 micrometers to 14 micrometers.

PHASE II: Develop tunable calibrated packaging technology and integrated electronics to create and display calibrated, user defined spectral output to represent very high temperature objects in test environments from room temperature to cryogenic operation.

PHASE III: Design refinement and limited production for government and contractor HWIL test facilities.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The entire hardware in the loop test community would benefit directly from this development. All weapon programs relying on infrared sensors against high contrast targets would benefit. Commercial products designed for fire fighting or search and rescue could use this product for developmental testing or training. Spectroscopy of gases for medical and environmental monitoring, semiconductor inspection, off indicators, printing, commercial and military night vision.

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AD Number: ADA355943, Recent Technology Developments for the Kinetic Kill Vehicle Hardware-In- The-Loop Simulator (KHILS), Murrer, Robert L., Jr.; Thompson, Rhoe A.; Coker, Charles F.,Report Date: 1998.

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KEYWORDS: HWIL, Blackbody Source, Infrared resistor array, Chalcogenide fiber, IR LED, Light Emitting Diode, IR laser diode, room temperature IR diode, negative luminescence.

MDA04-31 TITLE: High Temperature Multi-Band Infrared scene Generation Technology

TECHNOLOGY AREAS: Sensors, Space Platforms, Weapons

ACQUISITION PROGRAM: BMDS - MDA/TE, MDA/SE, MDA/AS, MDA/KI

OBJECTIVE: Develop novel infrared emissive technologies, delivering apparent temperatures at high dynamic range, to replace and supplement existing resistor array scene projector sources.

DESCRIPTION: The Missile Defense Agency (MDA) is interested in advancing the current state of the art for infrared scene generation and projection techniques, in which digital information is then fed into a calibrated projection system for presentation to a dual-band interceptor sensor. Current Hardware in the Loop Infrared (IR) projection technology is predominantly focused on use of Resistor Arrays to realistically simulate dynamic infrared objects and backgrounds at temperatures up to 700 Kelvin. Technology based on resistive arrays has many benefits including flicker-less emission, broadband output, greater than 512 by 512 pixel spatial resolution, and high frame rates. However, the dynamic range of this technology does not provide for radiometric duplication of the full range of target scenarios likely to be encountered by future MDA weapons systems. Current arrays have limitations in output, limiting the apparent temperature, and suffer from droop across the array due to resistive losses at high current operating conditions.

Alternative methods are needed to represent multi-band images of targets with hot engine exhausts or rocket plumes, and infrared countermeasures. Innovative approaches are required for simulation of spatially extended objects whose apparent temperature may exceed 3000K. For the purpose of defining approaches, the projector should be realizable for testing of a specific sensor having at least two bandpasses, two-microns wide anywhere within the 2-14 micron band. Ideally, the projection concept should be able to achieve at least 512 squared spatial resolution, provide a non-temporally-modulated output, and, if pixelated, achieve pixel response times of less than 1.25 msec. One approach may be to use arrays of IR light emitting diodes. Especially useful would be IR-LEDs capable of negative luminescence, for simulating cold scene temperatures below ambient. Preferably the diodes emit and absorb radiation in the 3-5 µm and 8-14 µm wavelength regions. In practice, the fundamental switching speed of IR light emitting diodes is in excess of 1 MHz. The frame rates that may be achieved are therefore determined not by the thermal time constant of each pixel but by the frequency of the multiplexer drive circuit.

Another approach would integrate steerable MEMS mirrors with IR sources for the coaxial scanning of a large 2-D or 1-D array of IR lasers or LEDs. The objective is a mixed thermal and narrow band spatial modulator of at least 400 individually controllable points (20 by 20). Amplitude control and blanking may be required on a frame-to-frame basis.

PHASE I: Develop a dual-band infrared projector concept. Develop and establish through simulation the trade space for meeting a variety of waveband and dynamic range requirements. A proof of concept demonstration is desired with a small number of elements.

PHASE II: Develop and demonstrate a large format, flicker-less, snapshot dual-band emissive array solution operating to cryogenic temperature to support MDA scene generation needs.

PHASE III: Design refinement and limited production for government and contractor HWIL test facilities.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The entire hardware in the loop test community would benefit directly from this development. All weapon programs relying on infrared sensors against high contrast targets would benefit. Commercial products designed for fire fighting or search and rescue could use this product for developmental testing or training. Spectroscopy of gases for medical and environmental monitoring, semiconductor inspection, off indicators, printing, commercial and military night vision are other applications.

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KEYWORDS: HWIL, Blackbody Source, Infrared resistor array, Infrared Scene Projection, IR LED, Light Emitting Diode, IR laser diode, room temperature IR diode, negative luminescence

MDA04-32 TITLE: <u>Sensitivity analysis for missile defense battlespace environment simulation and scene generation</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS - MDA/SE (System Engineering)

DESCRIPTION: Missile defense uses comprehensive computer codes that create scene simulations and that model the entire battlespace environment. These computer codes comprise models of the targets, the environment, and sensors. Yet, neither the environment nor the target can be described by a unique set of parameters. Rather, at any given time these parameters can cover a wide range of values. Moreover, a level of uncertainty is associated with these parameters. As a result, the battlespace environment simulation can estimate the anticipated signature only within some level of certainty. Yet, the sensors associated with missile defense must be able to respond to the full range of possible signatures that may be wider than those predicted by the models.

Moreover, while the simulated signatures may be very sensitive to some parameters, they may be less sensitive to others. A tool is desired that will be able to identify which parameters most influence the predicted signatures.

PHASE I: The contractor will select key elements of the Battlespace Environment and Signature Toolkit and demonstrate effective techniques for sensitivity analysis and uncertainty determination for the computer model.

PHASE II: The contractor will expand the sensitivity analysis and uncertainty determination to include additional models and to demonstrate uncertainty propagation among models. The contractor will create tools for effective data visualization that support the battlespace simulation toolkit.

PHASE III: Uncertainty analysis technique can be used for economic modeling, weather predictions, optimization decisions, etc.

PRIVATE SECTOR COMMERCIAL POTENTIAL: These methods can be applied in a number of commercial applications where code/model sensitivities can be assessed. This includes areas such as economic modeling, weather predictions and forecast.

REFERENCES: N. Gat, J. Barhen, and A. Carle, "Enhancement of MODTRAN 4 via Automatic Differentiation," Presented at the 22nd Annual Review Conference on Atmospheric Transmission and Radiance Models, June 1999, Hanscom AFB.

KEYWORDS: Automatic Differentiation; sensitivity analysis, uncertainty analysis, decision optimization

MDA04-33 TITLE: Plume model verification via sensitivity analysis

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS - MDA/SE (System Engineering)

DESCRIPTION: The present suite of plume codes is known not to match sensor plume measurements in many instances. The problems may be related to inappropriate or inaccurate model input parameters including user inputs, database parameters, or model internal parameters that are used to compute plume properties. In addition, problems may be associated with inadequate modeling of the plume phenomenology. The key point is that there are a very large number of possible causes to the observed mismatch between plume data and models.

Novel tools exist today to efficiently perform sensitivity analysis of plume prediction with respect to a large number of input variables. With these tools, it is possible to identify which input parameters most affect the computed output parameters; the actual values of such parameters may only be known within an uncertainty range. Moreover, using inverse solution techniques, optimal values for the sets of such suspect parameters can be established. The solution tool must simultaneously consider multiple measurements so that a common and consistent adjustment to the inputs and models is obtained. Additionally, the solution tool must consider the uncertainty of the measurements during the extraction of optimal parameters. Once identified, the physical reasonableness of the optimal values needs to be assessed. Finally, the modified model must be tested against an extensive set of experimental plume measurements as a part of the validation process.

PHASE I: The contractor will develop the algorithmic tools and computer codes needed for efficiently establishing the model output sensitivities to the model input parameters including engine and exhaust flow fields, radiation, and atmospheric propagation codes. The contractor will demonstrate an approach to obtaining the optimal input parameters to match sensor data. Finally, the contractor will demonstrate the computational technique with at least one set of model predictions to identify the most influential inputs.

PHASE II: Using multiple sensor data sources, the contractor will establish what code parameters might be responsible for model prediction mismatches with sensor data and propose the proper adjustments to the input parameters. The contractor will then validate such changes with several data sets for different target vehicles and different sensors.

PHASE III: Algorithmic tools developed under this effort are applicable to a variety of computer codes and simulations in all disciplines, including nuclear reactor modeling, meteorological prediction, atmospheric chemistry, and global scale phenomenology.

PRIVATE SECTOR COMMERCIAL POTENTIAL: These methods can be utilized for assessing the uncertainties related to commercial Computational Fluid Dynamic code (CFD) simulations. CFD codes are heavily used for trade studies, design, and analysis. Examples include nuclear reactor modeling, meteorological prediction, automotive, aircraft design, etc. Providing the domain of uncertainties related to grid generation, model correlations, and input variabilities can greatly reduce trial and error of CFD applications.

REFERENCES: N. Gat, J. Barhen, and A. Carle, "Enhancement of MODTRAN 4 via Automatic Differentiation," Presented at the 22nd Annual Review Conference on Atmospheric Transmission and Radiance Models, June 1999, Hanscom AFB.

KEYWORDS: Automatic Differentiation; sensitivity analysis, uncertainty analysis; model validation

MDA04-34 TITLE: Technologies to Improve Software Acquisition/Development Process

TECHNOLOGY AREAS: Air Platform, Information Systems, Space Platforms, Weapons

ACQUISITION PROGRAM: BMDS - MDA/MP (Manufacturing and Producibility)

OBJECTIVE: MDA is seeking innovative approaches to software that improves product capabilities, improves product quality and reliability, and reduces the time and cost of transitioning prototypes into production. Of special interest is the application of commercial software approaches, methods, and tools to mitigate problems encountered with legacy software, architectures, and languages, (e.g., ADA), in particular the reuse of legacy software.

DESCRIPTION: MDA is seeking innovative approaches to address improvements in the acquisition and/or development process for new software products and adaptation of existing software to changing situations (e.g., if the upgrade to an existing missile seeker is 5+ years after the initial software development, then a breakeven analysis maybe required for reuse of the existing software). Many missile defense systems use proprietary software often developed in a laboratory environment, and are subject to expensive, time-consuming custom integration into systems. The need is for process technologies that address the cost versus benefits of developing software for reuse, and if not developed for reuse, an analytical tool to determine if newly developed software is more beneficial.

Specific technology areas include, but not limited to:

· Object-Oriented / Universal Modeling Language (e.g., Rational Rose): MDA is interested in conversion of legacy codes into software that facilitates reuse and improves life cycle costs.

· Software Libraries (Functional Primitives): Many design algorithms and/or software models could be used as code generators for radar, electro-optic imaging, etc. and could be standardized for use across multiple MDA systems.

PHASE I: Develop conceptual software, firmware and hardware designs or modifications to existing software that address problem areas addressed above. Conceptual designs would include, but not be limited to, flowcharts, simulations and emulations, timing analyses, GUI designs (where applicable) and narrative descriptions of software operation.

PHASE II: Validate the feasibility of the software by demonstrating its use in the testing and integration of prototype items for MDA element systems, subsystems, or components. Validation would include, but not be limited to, software based system simulations, operation in test-beds, or operation in a demonstration sub-system. A partnership with the current or potential supplier of MDA element systems, subsystems or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

PHASE III: Successfully demonstrate new open/modular, non-proprietary, operating software. Demonstration would include, but not be limited to, demonstration in a real system or operation in a system level test-bed. This demonstration should show near term application to one or more MDA element systems, subsystems, or components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Most innovations in operational software are taking place in the commercial sector. DoD & MDA need infusions of commercially strategic/design tools/middle-ware and software architectures. The projected benefits of the innovation to commercial applications should be clear, whether they reduce cost, improve producibility, or performance or products that utilize the innovation process technology.

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KEYWORDS: universal modeling language, embedded software, new versus reuse tradeoffs, reliability, reduced costs, improved productivity

MDA04-35 TITLE: Innovative Manufacturing Process Improvements

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Space Platforms

ACQUISITION PROGRAM: BMDS - MDA/MP (Manufacturing and Producibility)

OBJECTIVE: Develop and apply innovative manufacturing processes that improve capabilities, product quality and reliability, reduce unit costs and enhance manufacturing yields and sub-systems and component performance. These innovations will be targeted at improving near term design, fabrication, and data management of key ballistic Missile defense technologies

DESCRIPTION: MDA is seeking innovative approaches and tools from small businesses that will allow economically feasible acquisition of new manufacturing process technologies for ballistic missile defense systems. These processes can range from improvements in fabrication of advanced materials (possibly an innovative alternative single process improvement), design engineering tools, tools to monitor manufacturing process development, etc through innovative application of methods and tools to improve manufacturing processes and procedures on current systems and subsystems. MDA is also interested in process technology that facilitates the transition of a product (breadboard, brass board or prototype) from an R&D environment to any manufacturing environment (commercial, defense or both).

Technical areas of interest: This topics focus is on innovations that can be developed/demonstrated or even inserted into the following areas are fabricated for missile defense systems:

· Passive Electro-Optic Sensors and Active LADAR: Infrared; (dual-band and multi band systems); angle-angle range direct detection and coherent LADARs
· Radars and RF Components: Advanced GaAs and wideband gap (WBG)
· Signal Processing, Data Fusion and Imaging
· Radiation Hardened Electronics Discrete components to functional subsystem radiation tolerant evaluation
· Propulsions: Boosters, divert and attitude control, nozzles, components, high temperature materials.
· Composite Materials and Structures For affordability and for systems improvement
· Power systems and Batteries: Advanced thermal batteries, lithium and lithium oxyhalide batteries, light weight solar cells, fuel cells
· Cryocoolers and Cryocooler components for interceptor IR systems and satellite IR detectors

PHASE I: Demonstrate that a new or innovative process technology can meet MDA needs including, where appropriate, a process technology roadmap for implementing promising approaches for near term insertion into BMD element systems, subsystems, or components. Opportunities are many and exist at discrete component up to system (element) level. A dialogue with the TPOCs listed is encouraged.

PHASE II: Validate the feasibility of the innovative manufacturing process by demonstrating its use in the testing and integration of prototype items for MDA element systems, subsystems, or components. Validation would include, but not be limited to, system simulations, operation in test-beds, or operation in a demonstration sub-system. A partnership with the current or potential supplier of MDA element systems, subsystems or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

PHASE III: Successfully demonstrate new open/modular, non-proprietary, innovative manufacturing process. Demonstration would include, but not be limited to, demonstration in a real system or operation in a system level test-bed. This demonstration should show near term application to one or more MDA element systems, subsystems, or components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Proposals should show how the innovation can benefit commercial business or should show that the innovation has benefits to both commercial and defense manufacturing methods. This topic is very receptive to manufacturing innovations that are being used in commercial manufacturing and could be applied to defense manufacturing. The projected benefits of the innovation to commercial applications should be clear, whether they reduce cost, improve producibility, or performance of products that utilize the innovation process technology.

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http://www.acq.osd.mil/bmdo/bmdolink/html/, http://www.acq.osd.mil/bmdo/bmdolink/html/basics.html.

KEYWORDS: process reliability, reduced costs, improved productivity

MDA04-36 TITLE: Manufacturing Technology for Radiation Hardened/Tolerant Systems

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Electronics, Space Platforms

ACQUISITION PROGRAM: BMDS - MDA/MP (Manufacturing and Producibility)

OBJECTIVE: MDA is seeking to strengthen the US industrial base for radiation hardened devices via innovative manufacturing technology that reduces the size, power and cost of Radiation Hardened Electronics, in particular sensor subsystems for ballistic missile defense systems (natural and nuclear environments), including application of, or modification to existing components/devices, whether commercial off-the-shelf (COTS) or military off-the-shelf (MOTS), but applied in a creative way to MDA systems, subsystems, or component requirements. The overall program goal is to expand on and leverage previous/on-going efforts which attempt to exploit, where possible, commercial technology, e.g., a CMOS foundry, by tailoring design rules for electronic devices to enhance radiation hardness/tolerance at the device level while leveraging COTS or other encapsulation techniques. A particular area of interest is the tradeoff between and/or the combination of mechanical, software and hardware approaches to radiation hardening/tolerancing. The results need to focus on more producible radiation hardened/tolerant ballistic missile defense systems.

DESCRIPTION: Many missile defense products are fabricated in an R&D/laboratory environment and are subject to expensive, time-consuming custom integration into systems. Product technology is transitioned from laboratory to factory without complete understanding of producibility constraints on product designs, e.g., one year lead times to obtain radiation hardened/tolerant devices for low lot quantity acquisitions. Innovative manufacturing technology can range from improvements in fabrication of advanced materials to innovative products that improve the capability of current systems and subsystems. This may involve basic industrial research and development, characterization testing of advanced materials, development of improved material manufacturing and component assembly processes, etc., that leads to technology insertion in an existing or planned MDA system. The goal is to enable more cost effective radiation hardened / tolerant missile defense products.

Technical areas of interest include, but are not limited to:

· System Shielding (Solar and/or Nuclear Radiation)

· System Life-limiting Electronics (e.g., Cryocooler Control Electronics, Field Programmable Gate Arrays, Memory, Up-Down and Cross-link Communications, etc.)

· Sensors and their Complementary Electronics (e.g., LADAR, IR Focal Plane Arrays)

· Sensor Optics (e.g., filters, mirrors and lenses) and techniques to harden sensors to both nuclear and laser radiation

· Power Generation (e.g., Solar Cell Arrays)

· Micro-Electro-Mechanical-Systems (e.g., Inertial Measurement Units for guidance and control)

PHASE I: Develop a comparative assessment of current versus proposed Radiation Hardened/Tolerant device design through manufacturing technology/methods, and identify innovation to be used in support of or integration into an MDA system or subsystem to increase performance, lower cost, or increase reliability.

PHASE II: Validate the feasibility of a radiation hardening/tolerancing technology by demonstrating its use in the testing and integration of prototype items for MDA element systems, subsystems, or components. Validation would include, but not be limited to, system simulations, operation in test-beds, or operation in a demonstration subsystem. A partnership with the current or potential supplier of MDA element systems, subsystems or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

PHASE III: Successfully demonstrate new open/modular, non-proprietary, radiation hardening/tolerancing technology. Demonstration would include, but not be limited to, demonstration in a real system or operation in a system level test-bed. This demonstration should show near term application to one or more MDA element systems, subsystems, or components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Most innovations in manufacturing processes take place at the supplier/subcontractor level. Technologies developed are applicable in both military and commercial arenas including microelectronics and satellites. These improvements will have application in future DoD, Intelligence Community, NASA and commercial ventures by providing enhanced microelectronic systems, such as faster processors for on-board processing, increased memory, and enhanced power generation, and increase the operational lifespan of systems.

REFERENCES:
http://www.acq.osd.mil/bmdo/bmdolink/html/, http://www.acq.osd.mil/bmdo/bmdolink/html/basics.html

MDA04-37 TITLE: Ballistic Missile System Innovative Power Storage Devices

TECHNOLOGY AREAS: Air Platform, Ground/Sea Vehicles, Space Platforms, Weapons

ACQUISITION PROGRAM: BMDS - MDA/MP (Manufacturing and Producibility)

OBJECTIVE: MDA is seeking to improve the quality, reliability and producibility of batteries/power sources in ballistic missile defense systems, including the application or modification of existing products, whether commercial off-the-shelf (COTS) or military off-the-shelf (MOTS), when applied in a creative way to unique MDA system, subsystem or component requirements.

DESCRIPTION: Many missile defense battery products are manufactured in low volume and the technologies are transitioned from the laboratory to the factory without complete understanding of producibility constraints on product designs. Therefore, MDA is interested in innovative product enhancements that improve consistency and manufacturability while incorporating evolving technologies for integration into MDA systems. This can range from improvements in fabrication of advanced materials to innovative products that improve the capability of current systems and subsystems. The goal is to enhance producibility of missile defense products, reduce unit cost, and improve product reliability and performance to support future capabilities.

Technical Area of Interest Include, but are not limited to:

· Primary Thermal Batteries: Innovations in higher energy/power density thermal batteries, i.e. $LiFeS_2$, $LiCoS_2$.

· Primary Lithium Oxyhalide Batteries: Innovations in prototyping and production variants to support current and future missile defense applications.

· Secondary Li-Ion Batteries: Develop design variations for current or progressive Li-Ion batteries for aerospace systems applications. Variations on Li-Ion batteries also required for high pulse power directed-energy and LADAR systems.

· Explore use of Li battery/ultra-capacitor hybrids to meet missile defense niche applications.

· Development and exploitation of CAM/CAD tools to aid battery design, reduce non-recurring engineering costs, and shorten lead times.

· Research and develop improved electrochemical processing techniques to lower costs and improve battery safety, size, weight, and improved electrolyte transport numbers.

· Enabling technologies to produce extremely lightweight, safe, relatively inexpensive, inherently powerful primary batteries with enhanced consistency, producibility and manufacturability are necessary for mission success.

PHASE I: Develop conceptual framework for battery design/design modification for MDA integration into system or subsystem to increase performance, lower cost and increase reliability and producibility.

PHASE II: Validate the feasibility of a power storage device technology by demonstrating its use in the testing and integration of prototype items for MDA element systems, subsystems, or components. Validation would include, but not be limited to, system simulations, operation in test-beds, or operation in a demonstration sub-system. A partnership with the current or potential supplier of MDA element systems, subsystems or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

PHASE III. Successfully demonstrate new open/modular, non-proprietary, power storage device technology. Demonstration would include, but not be limited to, demonstration in a real system or operation in a system level test-bed. This demonstration should show near term application to one or more MDA element systems, subsystems, or components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Thermal batteries are used in most commercial launch vehicles to power fin actuators, actuators for thrust vector controls, squibs and pyrotechnics for staging and other events during the launch sequence. Once a commercial satellite is launched, electric power is provided by rechargeable batteries, which are recharged by solar panels on the satellite. Rechargeable Lithium Ion batteries are now being considered for use in the commercial space industry because of their extremely high energy density, 3 times that of current technology. Lithium Oxyhalide Batteries, as their cost is reduced through producibility initiatives, could replace some thermal primary reserved batteries in commercial applications where weight is a factor. Finally, many of the manufacturing and producibility enhancements for batteries for MDA would directly impact the commercial manufacturing lines of the companies supplying these batteries. Improved electrochemical processing techniques would directly affect production in the commercial sector which relies heavily on Lithium Ion, Lithium Metal Hydride and other Lithium batteries to power computers, portable tools, and electric vehicles.

REFERENCES:
http://www.acq.osd.mil/bmdo/bmdolink/html/, http://www.acq.osd.mil/bmdo/bmdolink/html/basics.html.

MDA04-38 TITLE: Ballistic Missile Innovative Electro-Optic Products

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: BMDS - MDA/MP (Manufacturing and Producibility)

OBJECTIVE: MDA is seeking innovative products that improve multi-spectral imaging and optical sensor capability, reliability and producibility in Ballistic Missile Defense systems. Innovations include, but are not limited to, application of or modification to existing products whether Commercial-off-the-shelf (COTS) or Military-off-the-shelf (MOTS) that are applied in creative ways to MDA systems, subsystems, or component requirements.

DESCRIPTION: Many missile defense products are fabricated in an R&D or laboratory environment and are subjected to expensive, time-consuming custom integration into systems. MDA is seeking innovative approaches that will allow economically feasible acquisition of new process technologies for components of the ballistic missile defense system. This can range from improvements in fabrication of advanced materials through innovative application of methods and tools to improve manufacturing processes and procedures on current systems and subsystems. MDA is also interested in process technology that facilitates the transition of a product (breadboard, brass board or prototype) from an R&D environment to any manufacturing environment (commercial, defense or both).

Technical areas of interest include, but are not limited to performance parameters such as pixel density, sensitivity, spectral coverage and cutoff wavelengths relative to manufacturing metrics such as repeatability and yields that enhance producibility and/or lower production costs of:

· Infrared Focal Plane Arrays, all wavebands but with particular emphasis on the VLWIR and with consideration given to reduction in power dissipation, higher operating temperature and improved performance uniformity

· Dual- and multi-color systems,

· Laser Radar: Angle-angle range direct detection and coherent LADAR systems, subsystems and components (transmitters/receivers) such as laser amplifier, oscillators, pump diode, Intensified Photo Diode (IPD) and Photo Multiplier Tube (PMT) arrays,

PHASE I: Develop conceptual framework for Electro-Optic product design or modification that will improve performance, lower cost, or increase reliability of BMD element systems, subsystems, or components.

PHASE II: Validate the feasibility of an electro-optic product technology by demonstrating its use in the testing and integration of prototype items for MDA element systems, subsystems, or components. Validation would include, but not be limited to, system simulations, operation in test-beds, or operation in a demonstration sub-system. A partnership with the current or potential supplier of MDA element systems, subsystems or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

PHASE III: Successfully demonstrate new open/modular, non-proprietary, electro-optic product technology. Demonstration would include, but not be limited to, demonstration in a real system or operation in a system level test-bed. This demonstration should show near term application to one or more MDA element systems, subsystems, or components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Innovations developed under this topics will benefit both DoD and commercial space and terrestrial programs. Possible uses for these products include missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. Enhancements to imaging quality show significant potential.

REFERENCES:
http://www.acq.osd.mil/bmdo/bmdolink/html/, http://www.acq.osd.mil/bmdo/bmdolink/html/basics.html, http://www.acq.osd.mil/bmdo/bmdolink/html/sensor.html, http://www.iriacenter.com, Infrared & Electro-Optic Systems Handbook, eds. Wolfe and Zissis, Infrared Detectors and Focal Plane Arrays VII Proceedings, Eustace L. Dereniak, Optical Sciences Ctr./Univ. of Arizona; Robert E. Sampson

MDA04-39 TITLE: Ballistic Missile Innovative Radar and RF Products

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: BMDS - MDA/MP (Manufacturing and Producibility)

OBJECTIVE: MDA is seeking innovative products that improve Radars and RF system capability, reliability and producibility in Ballistic Missile Defense systems. Innovations include, but are not limited to, application or modification to existing products whether Commercial-off-the-shelf (COTS) or Military-off-the-shelf (MOTS) that are applied in creative ways to MDA systems, subsystems, or component requirements.

DESCRIPTION: Many missile defense products are fabricated in an R&D or laboratory environment and are subjected to expensive, time-consuming custom integration into systems. MDA is seeking innovative approaches that will allow economically feasible acquisition of new process technologies for components of the ballistic missile defense system. This can range from improvements in fabrication of advanced materials through innovative application of methods and tools to improve manufacturing processes and procedures on current systems and subsystems. MDA is also interested in process technology that facilitates the transition of a product (breadboard, brass board or prototype) from an R&D environment to any manufacturing environment (commercial, defense or both).

Technical areas of interest include, but are not limited to:

· Advanced gallium arsenide (GaAs) and wide band gap (WBG) high power amplifiers/devices in the frequency range from UHF through Ka Band. Focus areas include: high throughput, high yield, wafer manufacturing; high throughput, high yield discrete device production and characterization, as well as performance improvements; and amplifier module manufacturability, miniaturization, reliability that enhance performance, extend service life, and/or reduce production costs.

· Solid State Transmitters such as IMPATT diode and transistor based design, manufacturability, reliability improvements that enhance performance or lower production costs.

· Thermal Management systems such as improvements in subsystem active and passive cooling, heat conduction and related manufacturability improvements that enhance performance or lower production costs. Focus areas include thermal management at the radar T/R module-level (such as heat spreaders in the high power amplifier device material stack-up) as well as novel antenna structure designs.

· Software defined waveform generators and receivers such as programmable telemetry transceivers, associated software reliability and manufacturability that enhance performance or lower production costs.

· MMIC packaging and High-Density Interconnects (HDI) such as three-dimensional high-density interconnect, flip-chip, and high frequency/high power density packaging designs and manufacturability improvements.

· Multi-band frequency agile data links such as reprogrammable multiband radio frequency data links which provides interoperability between multiple platforms with little or no modifications and least possible cost by permitting adaptation to the specific data link requirements through software loading.

· Multi-band Antennas such as phased array antenna structure, adaptive beamforming, and wideband T/R modules design and manufacturing improvements.

PHASE I: Develop conceptual framework for Radar or RF system product design or modification that will improve performance, lower cost, or increase reliability of BMD element systems, subsystems, or components.

PHASE II: Validate the feasibility of a radar and/or RF product technology by demonstrating its use in the testing and integration of prototype items for MDA element systems, subsystems, or components. Validation would include, but not be limited to, system simulations, operation in test-beds, or operation in a demonstration sub-system. A partnership with the current or potential supplier of MDA element systems, subsystems or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

PHASE III. Successfully demonstrate new open/modular, non-proprietary, radar and/or RF product technology. Demonstration would include, but not be limited to, demonstration in a real system or operation in a system level test-bed. This demonstration should show near term application to one or more MDA element systems, subsystems, or components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Radar and RF products are widely used in commercial industry and would benefit in areas including: solid-state air traffic control radars; high power amplifiers for cellular telephone base stations, thermal management materials for the electronics industry; semiconductor device developments and mixed signal devices for the telecommunications industry, high power density packaging designs for cellular telephones and hand held computers. Many of the technologies under this topic would be directly applicable to the commercial space telecommunications industry including RF data links for high bandwidth satellite communications.

REFERENCES:
http://www.acq.osd.mil/bmdo/bmdolink/html/, http://www.acq.osd.mil/bmdo/bmdolink/html/basics.html.

MDA04-40 TITLE: Ballistic Missile Innovative Signal Processing, Data Fusion and Imaging Products

TECHNOLOGY AREAS: Information Systems, Electronics

ACQUISITION PROGRAM: BMDS - MDA/MP (Manufacturing and Producibility)

OBJECTIVE: MDA is seeking innovative products that improve Signal Processing, Data Fusion and Imaging system capability, reliability and producibility in Ballistic Missile Defense systems. Innovations include, but are not limited to, application or modification to existing products whether Commercial-off-the-shelf (COTS) or Military–off–the–shelf (MOTS) that are applied in creative ways to MDA systems, subsystems, or component requirements.

DESCRIPTION: Many missile defense products are fabricated in an R&D or laboratory environment and are subjected to expensive, time-consuming custom integration into systems. MDA is seeking innovative approaches that will allow economically feasible acquisition of new process technologies for components of the ballistic missile defense system. This can range from improvements in fabrication of advanced materials through innovative application of methods and tools to improve manufacturing processes and procedures on current systems and subsystems. MDA is also interested in process technology that facilitates the transition of a product (breadboard, brass board or prototype) from an R&D environment to any manufacturing environment (commercial, defense or both).

Technical areas of interest include, but are not limited to:

· Advanced Optical Processors such as Fourier optic, optical system and component, sensor array, A/D converter, processor and algorithm designs and manufacturability improvements or miniaturization that enhance performance or lower production costs.

· Flow Motion Sensors such as high integration single of multichip system, algorithm or sensor array designs and manufacturability improvements that enhance performance or lower production costs.

· Wide instantaneous bandwidth processing of multiple waveforms such as Pseudorandom noise (PRN) code, chaotic waveform and ultra-wideband modulation format designs or implementations that enhance performance or lower production costs.

PHASE I: Develop conceptual framework for Signal Processing, Data Fusion and Imaging system product design or modification that will improve performance, lower cost, or increase reliability of BMD element systems, subsystems, or components.

PHASE II: Validate the feasibility of a signal processing, data fusion and imaging system product technology by demonstrating its use in the testing and integration of prototype items for MDA element systems, subsystems, or components. Validation would include, but not be limited to, system simulations, operation in test-beds, or operation in a demonstration sub-system. A partnership with a current or potential supplier of MDA systems, subsystems or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

PHASE III. Successfully demonstrate new open/modular, non-proprietary, signal processing, data fusion and imaging system product technology. Demonstration would include, but not be limited to, demonstration in a real system or operation in a system level test-bed. This demonstration should show near term application to one or more MDA element systems, subsystems, or components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Enahncements to signal processing, data fusion, and imaging have significant potential for commercial use in such areas as Medical Imaging, satellite environmental monitoring, space exploration, law enforcement and weather radar. There are numerous military applications as well outside of MDA, especially in instrumentation radar used for phenomenology and space surveillance.

REFERENCES:
http://www.acq.osd.mil/bmdo/bmdolink/html/, http://www.acq.osd.mil/bmdo/bmdolink/html/basics.html.

MDA04-41 TITLE: <u>Ballistic Missile System Composite Materials and Structures</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: BMDS - MDA/MP (Manufacturing and Producibility)

OBJECTIVE: MDA is seeking innovative products that improve capability, reliability, and producibility in ballistic missile defense systems, including application of or modification of existing products, whether commercial off-the-shelf (COTS) or military off-the-shelf (MOTS), but applied in a creative way to unique MDA systems, sub systems, or component requirements.

DESCRIPTION: Many missile defense products are fabricated in an R&D/laboratory environment and are subject to expensive, time-consuming custom integration into systems. Product technology is transitioned from laboratory to factory without complete understanding of producibility constraints on product designs. Therefore, MDA is interested in innovative product improvements and innovative product applications of constantly evolving products technologies, within a path toward integration into MDA systems. This can range from improvements in fabrication of advanced materials to innovative products that improve the capability of current systems and subsystems. This may involve basic industrial research and development, characterization testing of advanced materials, development of improved material manufacturing and component assembly processes, etc., that lead to a specific product application. The goal is to enhance producibility of missile defense composite material and structure products, reduce cost, or improve product reliability and performance.

Technical areas of interest include, but are not limited to:

. Polymer matrix and metal matrix graphite and ceramic composites for structures and thermal management systems capitalizing on more recent rapid prototyping composite manufacturing techniques to reduce cost, weight, and lead time for MDA subsystems.

· Interceptor Structures: Electronic enclosure assemblies, EKV EU Compression Clips and Rings, EU Heatsink, EKV EU Housing and Covers, EKV Hardened Sunshade, and Sensor Platform Mirrors and Support Structures, THAAD DACS ACS Manifold, Aerodynamic fins.

· RF antenna structures: Use of lightweight composite materials and advance thermal management approaches for both Ground Based Mid-Course and Terminal Defense layers.

· Missile Canisters: Use of more recent manufacturing improvements in commercial industry to reduce cost and lead-time on large structures such as Missile Canisters. Design focus areas include weight reduction or parts count reduction for Next Generation Shipping/Launch Canisters and Next Generation Missile Round Pallet.

· Integrated thermal/structural aeroshells/shrouds: Replace the current airframe manufacturing process and designing a one-step infusion process for stitched glass knitted bundle pre-forms for application to low cost, lightweight, and high performance aeroshells and shrouds.

PHASE I: Develop conceptual framework for composite material and structure product design or design modification, which would be used for MDA integration into a system or subsystem to increase performance, lower cost, or increase reliability.

PHASE II: Validate the feasibility of a composite materials and/or structures technology by demonstrating its use in the testing and integration of prototype items for MDA element systems, subsystems, or components. Validation would include, but not be limited to, system simulations, operation in test-beds, or operation in a demonstration sub-system. A partnership with a current or potential supplier of MDA systems, subsystems or components is highly desirable. Identify any commercial benefit or application opportunities of the innovation.

PHASE III: Successfully demonstrate new open/modular, non-proprietary, composite materials and/or structures technology. Demonstration would include, but not be limited to, demonstration in a real system or operation in a system level test-bed. This demonstration should show near term application to one or more MDA element systems, subsystems, or components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Most innovations in manufacturing processes take place at the supplier/subcontractor level. The proposals should show how the innovation can benefit commercial business or should show that the innovation has benefits to both commercial and defense manufacturing methods. The projected benefits of the innovation to commercial applications should be clear, whether they reduce cost, or improve producibility or performance of products that utilize innovative process technology.

REFERENCES:
http://www.acq.osd.mil/bmdo/bmdolink/html/, http://www.acq.osd.mil/bmdo/bmdolink/html/basics.html

MDA04-42 TITLE: Adaptive Computing for Surveillance and Seeker Applications

TECHNOLOGY AREAS: Information Systems, Battlespace

ACQUISITION PROGRAM: BMDS - MDA/MP (Manufacturing and Producibility)

OBJECTIVE: The objective of this program is to research innovative hardware and software technologies necessary to efficiently and cost effectively apply the capability for adaptive and/or reconfigurable computing technology to ballistic missile defense (BMD) surveillance and missile seeker applications.

DESCRIPTION: This program will research and demonstrate adaptive and reconfigurable computing technologies that can readily adapt hardware functionality to support BMD surveillance and missile seeker applications, such as information (data, image, video) processing, compression and transmission. Computing technologies can be proposed in either analog or digital architectures.

Digital: The most advanced adaptive and reconfigurable computing systems are in-field, as well as in-mission, hardware adaptable processing architectures. Adaptive and reconfigurable computers can have both fine-grained architectures based on Field Programmable Gate Array logic and coarse-grained architectures such as multiple processor elements on a chip with a reconfigurable interconnect fabric. As technology advances, these computers will have various combinations of microprocessors, memory structures, interface elements, digital signal processing elements, and programmable logic either on a single chip or on a circuit card.

Analog: Flexible analog architectures, at least within the restricted domain of focal plane arrays and perhaps ladars and/or radars can be made flexible enough to support a great diversity of designs by simply reprogramming gains, offsets, filter characteristics, and other analog-domain topological and parametric constraints through software-only modification, thereby eliminating the expense and time associated with customized front ends. A prospective class of analog architectures that support reconfigurability within system are sought, which can be readily and compactly merged with the companion digital portions of an architecture to create a software-definable surveillance or seeker system. In principle, such a system could be rapidly reconfigured to accommodate the attachment of new, more advanced sensors / FPAs with less retrofit burden and more rapidly. The approach is extensible to other parts of surveillance and seeker systems, to include mirror control, cryocoolers (if applicable), propulsion, and telemetry interfaces. The approach may be attractive not only to satellites and interceptors, but also to UAV/UCAV platforms.

Technologies of interest include architectures, hardware developments, programming (configuration) environments, and applications/demonstrations that lead toward technology insertion into an existing or planned MDA system.

PHASE I: Select an MDA surveillance and/or missile seeker applications, which can benefit from adaptive, reconfigurable technologies and define the demonstration and establish requirements. Survey adaptive and reconfigurable architectures and choose a development platform (hardware and software) for Phase II. Consideration should be given to demonstrating a path to radiation hardness of the concept that is commensurate with the application. Phase I may include a conceptual demonstration. Phase I proposals should demonstrate the widest range of applicability (for example, for an analog technique, a variety of different focal plane arrays, including multicolor and odd pixel formats). Attention should be paid not only to the flexibility, but also to the means by which reconfiguration is initiated and managed. Develop a Phase II development and demonstration plan. Outline a commercialization strategy and plan.

PHASE II: Validate, via an MDA system and in collaboration with a MDA system or subsystem contractor, the feasibility and benefit of the adaptive/reconfigurable computing concept by demonstrating its use in prototype items for MDA element systems, subsystems, or components. A partnership with the current or potential supplier of MDA element systems, subsystems, or components is highly desirable. For an analog front-end architecture, the offeror must construct a prototype and demonstrate its ability to reconfigure through software only using at least three different focal plane arrays. The approaches that can achieve plug-and-play or near plug-and-play with the smallest number of external (glue) components are believed to represent the best of the possible classes of implementation. Identify any commercial application of technology or opportunities of benefit from using the innovation.

PHASE III: Successful demonstration of the adaptive/reconfigurable computing concept technology. Demonstration should show near-term application to one or more BMD element systems, subsystems, or component, and also verify the radiation hardness of the concept either by testing or analysis. Demonstration would include, but not be limited to, demonstration in a real MDA system or operation in a system level test-bed.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Reconfigurable computing technology can be applied to any military or commercial system requiring image/video processing and compression.

REFERENCES:
What is Reconfigurable computing?, http://pw1.netcom.com/~optmagic/reconfigure/whatisrc.html
Memon, N., and R. Anasari. Handbook of Image & Video Processing. Academic Press, 2000.
Xilinx Digital Video web page & Related Features web pages: http://www.xilinx.com/esp/dvt.htm
Rooks, J., Lyke, J.; and Linderman, R. "Wafer Scale Signal Processors and Reconfigurable Processors in a 3-Dimensional Package", GOMAC 2002 Digest of Papers.

Paul LeVan, James Lyke, James R. Waterman, James R. Duffey, and Brandon Paulsen. "The Passive Sensor Subsystem for DITP - Current Status and Projected Performance", 2001 IEEE Aerospace Conference Proceedings (Big Sky, Montana, 10-17 March 2001).

P. McGuirk, J.C. Lyke, G.W. Donohoe "Malleable Signal Processor: A General-purpose Module for Sensor Integration", Military Applications of Programmable Logic Devices (MAPLD) 2000, Sept. 26-28, 2000.

Y. Kinashi, R. Linderman, and J. Lyke, "DITP: A Flexible miniaturized Sensor Fusion Processor for next Generation Interceptor Seekers and Surveillance Sensors", Proc. Of the 7th Annual AIAA/BMDO Technology Readiness Conference and Exhibit, Colorado Springs, CO. August 3-6, 1998.

KEYWORDS: Reconfigurable computing, Adaptive Computing Systems, Image Compression, Field Programmable Gate Array, Hardware Software Co-Design

MDA04-43 TITLE: Unstructured Knowledge Integration for Range and Space Launch Support

TECHNOLOGY AREAS: Information Systems, Space Platforms

ACQUISITION PROGRAM: BMDS - MDA/BC (Battle Management/Command and Control)

OBJECTIVE: Use an ontology-based approach to provide a practical and scaleable solution to integrating unstructured data with structured data from multiple data sources situated in diverse organizations involved in space launch and range operations.

DESCRIPTION: Space launch and range operations at the national ranges involve many different organizations working together to perform complex and technically demanding evolutions. For example, the 45th Space Wing (45 SW), provides space launch and range support for Department of Defense (DoD), civil, and commercial space launch missions. Support is also provided to DoD submarine launched ballistic missile Test and Evaluation missions. To provide this support the 45 SW operates and maintains the Eastern Range. It includes launch complexes, processing facilities, tracking radar, optical systems, telemetry, command destruct systems, and communications-computer systems. This demanding mission is performed primarily through several major service contracts that provide the multitude of services and functions needed to support launch and range operations. To perform its mission the 45 SW and its contractors must actively work with the many other organizations involved in launch and range operations. The diversity of organizations involved in launch and range operations significantly increase the need for effective communication and coordination in performing these complex and technically demanding activities.

Many of these organizations have leveraged information technology internally to improve effectiveness and efficiency so that much of the relevant information is in an automated form in various data stores. However, the communication and coordination between the diverse organizations involved remains a mostly manual, paper-based process that depends upon frequent meetings to exchange information. While the value of effectively sharing and integrating information among the many organizations involved in space launch is recognized and systems can be electronically connected, technical barriers exist. Every organization involved uses different approaches or schema for identifying, describing and organizing the same types of information. This diversity of approach results in different semantics and taxonomies, which makes the automated sharing and integration of information among different organizations difficult. This problem can be at least partially addressed by establishing an common ontology or metadata model as a reference for integrating the diverse data sources. This approach has been particularly useful with structured data found in relational databases or XML files. However, much of the information of interest in an organization is created and used in unstructured or semi-structured documents such as email messages letters, reports and briefings.

This unstructured or semi-structured data, while representing a significant part of most organizations' knowledge base, is even more difficult to integrate beyond the document level. The content of the documents usually remains opaque to integration efforts, with perhaps some separately identified keywords as a guide for search and retrieval. This kind of information access is insufficient for "content extraction" from unstructured sources, which is needed to semantically analyze unstructured knowledge. Likewise, search tools, such as the indexing systems common on the web, depend upon the user to craft appropriate queries and are unable to access meaning from text. Much of an organization's information often remains locked away in these documents. However, the same common ontology or metadata model of the data that would integrate information from structured data sources could also be the key to effectively integrating the contend of documents and other unstructured data. This integrated data could then be readily searched and used seamlessly with structured data.

While a variety of efforts are underway in the commercial and academic world to integrate and share information from different databases, few consider unstructured information at a semantic level and none address the subject domain of space launch and range operations. In addition, they do not consider the diverse nature of the organizations involved, or the dynamic environment. An approach is needed to use an ontology related to space launch and range operations as a basis for integrating the content of documents and other unstructured data with structured data. It would need to address the matching of document content with the concepts in the ontology and provide a means to leverage this semantic matching to deliver needed information to a user. It should be able to work with common office documents such as email, reports and briefings in commonly used formats. In addition, the approach should allow unstructured data to be transformed into a structured format for integration with legacy databases. Finally, it should also consider ways to expand the ontology based upon the discovered content of the documents, perhaps via tools which assist a knowledgeable user.

PHASE I: Describe in detail the proposed concept for integrating unstructured data with structured data with particular attention to the approach for matching of document content with an ontology related to space launch and range operations.

PHASE II: Develop and demonstrate a functioning prototype system that addresses the needs as indicated above and which addresses common forms and formats of unstructured information used for space launch and range operations. This prototype would encompass at least three sources of unstructured data in different organizations and provide a web-based interface for individual users. Demonstrate the system integrating data from various documents with structured data.

PHASE III: The desired result of phase III is a set of ontology-based products for practical integration, search, retrieval and transformation of unstructured technical and management information required for space launch and range operations. These products would serve to unify structured data (relational databases) with unstructured data (web pages, documents, email).

PRIVATE SECTOR COMMERCIAL POTENTIAL: While the space launch industry would be an immediate and direct beneficiary of this effort, the underlying problems addressed exist in any industry or government environment where diverse organizations must cooperate in multiple ways and there is a need to dynamically share and integrate unstructured technical and management information. On the commercial side, virtually any joint venture between technical companies would be a candidate and on the government side agencies involved in homeland security could find it useful.

REFERENCES: ISO/IEC 11179

KEYWORDS: Metadata; knowledge management; data semantics; data integration; ontology, unstructured data, search, taxonomy; space launch, range operations; web-based interface

MDA04-44 TITLE: <u>Fuselet Technology for Decision-Quality Missile Threat and Targeting Information</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS - MDA/BC (Battle Management/Command and Control)

OBJECTIVE: Develop an information management system capability that provides a secure runtime environment for interoperable, lightweight, distributed, and programmable software agents (fuselets) that subscribe to multiple sensor and intelligence data sources and produce decision-quality missile threat and targeting information.

DESCRIPTION: The Joint Battlespace Infosphere (JBI) is a as described in two summer study reports, Information Management to Support the Warrior (1998) [1], and Building the Joint Battlespace Infosphere (1999) [2]. Technically, the JBI information management system (a.k.a., Platform) employs Publish, Subscribe, Query, Transform, and Control core services to deliver decision-quality information in a secure and assured fashion with the desired Quality of Service (QoS) to all users at all echelons. Applications that interoperate with the JBI Platform are called JBI Clients. JBI Clients share information objects with each other through the JBI infrastructure through publish, subscribe and query mechanisms provided by the Platform. For example, one client would subscribe to some type of information, which is delivered by the JBI Platform when another client publishes that type of information some time in the future. Published information is also persisted so that clients can query historical information. The JBI control core service provides such capabilities as authentication, authorization, and information assurance. The JBI transform core service enhances the value of the information delivered by the Platform through mechanisms (e.g., filtering, aggregation) that tailor the information delivered to fit the specific needs of the warfighter and mission. An instance of the JBI is a dynamic system that is "stood up" for a specific purpose or mission, and is flexible to the evolving needs over time of a diverse and changing membership set of clients.

The JBI is built on four key concepts:
1. Information exchange through publish, subscribe and query,
2. Transformation of data into knowledge via fuselets,
3. Distributed collaboration through shared, updateable info objects, and
4. Assigned unit incorporation via force templates.

The focus of this topic is to help implement the design space, as defined in [3], for JBI fuselets in the context of Ballistic Missile Defense (BMD). This document describes the following JBI fuselet system components:
1. Production Environment
2. Library
3. Registration Utilities
4. Server
5. Runtime Management Environment

Fuselets are developed in a Production Environment and may be stored in a Fuselet Library for subsequent use. To deploy fuselets within an instance of the JBI, Registration Utilities are used to register them with a JBI and store them in the JBI repository. A Fuselet Server is used to instantiate a fuselet (e.g., supply parameters), and invoke them. Once invoked, running fuselet instances are monitored – and, if necessary, controlled – using a Fuselet Runtime Management Environment. Depending on the approach, some of these component capabilities might actually be functionally resident within the same physical system or subsystem of the implementation.

The specific focus of this topic is to provide a secure fuselet runtime environment (emphasizing the last three components listed above) that facilitates the processing, analysis and correlation of multiple sensor and intelligence data sources to produce decision-quality missile threat and targeting information. Only rudimentary support for the production of fuselets (e.g., a scripting language and interpreter, or a Java Virtual Machine) and the library component (e.g., simple file system) will be sought under this topic for research and development. This topic is interested in exploring the technical areas such as how to register fuselets with a JBI, how to invoke them and under what conditions, what the security implications are for fuselet transformation functions, and how to monitor and control the coordinated operations of a collection of running fuselets. The domain of application that is of interest for the technical concepts and capabilities developed under this topic is information management for the effective utilization of ground and sea-based interceptors, air/space launched intercept missiles, intelligence, and sensors on land, at sea, and in space, as well as other means of missile threat deterrence for the United States and its deployed forces, friends, and allies.

PHASE I: Develop a design for a JBI fuselet execution environment that would provide a secure runtime environment for fuselet processing that subscribes to and queries multiple sensor and intelligence data sources, and publishes decision-quality missile threat and targeting information. A final report will capture the lessons learned, important issues, and recommendations of the performing organization with regard to the technical areas of interest.

PHASE II: Implement a proof-of-concept prototype of the fuselet execution environment designed in Phase I that demonstrates the value of fuselets in producing decision-quality missile threat and targeting information.

PHASE III: A primary example of a possible dual-use application of this technology is in the area of secure, distributed internet application development.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The private-sector application of the fuselet execution environment developed would benefit industry through it's powerful data mining capability for extracting high-level representations (patterns and models) from data regarding customers, suppliers, partners, competitors, and other decision-quality information relating to many business interests.

REFERENCES:
[1] Information Management to Support the Warrior, SAB-TR-98-02, Dec 1998
[2] Building the Joint Battlespace Infosphere, Volumes 1 and 2, SAB-TR-99-02, Dec 1999
[3] Fuselet Definition Document, available at:
http://www.if.afrl.af.mil/tech/programs/jbi/documents/fuselet_definition.doc
[4] AFRL JBI Program, http://www.if.afrl.af.mil

KEYWORDS: JBI, fuselet, missile defense, sensors, security, information management, software agents, fusion, runtime support environment

MDA04-45 TITLE: Communication Alternatives for Missile Communications

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS - MDA/BC (Battle Management/Command and Control)

OBJECTIVE: Provide analysis of a proposed solution for communications to missiles in the MDA architecture and provide prototyping of hardware that would be provided on the missile to provide an advanced BLOC connectivity to/from the missile.

DESCRIPTION: The future communication architecture for MDA is not finalized. In particular, the optimum communications choice for communications to/from missiles for the future MDA needs to be analyzed in detail. For a particular communications architecture, this involves analysis on the level of protection provided by a communications link, the bandwidth available over the link, the ability to provide Beyond Line Of Sight (BLOS) connectivity, the effects of latency, the size, weight, and power of a candidate communications payload, security, and the cost of a proposed communications system. Most critically, this analysis must consider communications alternatives that are planned for future military satellite communications systems such as the Transformational Communications Architecture (TCA) and the Mobile User Objective System (MUOS). A means of providing robustness to the link with the use of Multiple Input Multiple Output (MIMO) techniques should also be included in the analysis.

PHASE I: The contractor will propose an optimum methodology for performing tradeoffs necessary to determine 2 or 3 logical choices for providing connectivity to missiles within the evolving MDA architecture. The output will be a methodology that discusses communications systems and hardware. Modeling and simulation may provide an additional verification of candidate modes of connectivity. Attention must be paid to ongoing efforts within the DoD for communications connectivity to weapons.

PHASE II: The contractor will select 1 or 2 proposed communications schemes developed in Phase 1 and prototype communications hardware that could be used for 2-way communications connectivity. The proposed schemes must be picked for their optimum mix of performance characteristics as listed under the description above.

PHASE III: This effort will seek to transition the product of a communications alternative for use on missiles within the MDA architecture. The contractor must work with MDA prime contractors to maximize the transfer of this development to MDA.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Other efforts within the DoD are focused on 2-way data links to weapons systems and this technology will most likely be transferred to those programs. The number of weapons that could ultimately use this technology would be substantial.

REFERENCES: DARPA Tactical Targeting and Network Technology (TTNT) program http://dtsn.darpa.mil/ixo/programdetail.asp?progid=9
DARPA MIMO program, the Transformational Communications Architecture (TCA) from the National Security and Space Architecture (NSSA) office.

MDA04-46 TITLE: Reconfigurable Computing for Missile C4I

TECHNOLOGY AREAS: Information Systems, Battlespace

ACQUISITION PROGRAM: BMDS - MDA/BC (Battle Management/Command and Control)

OBJECTIVE: The objective of this program is to research innovative hardware and software technologies necessary to efficiently and cost effectively apply Reconfigurable Computing (RC) technology to missile C4I applications.

DESCRIPTION: This program will research and demonstrate adaptive and reconfigurable computing technologies that can readily adapt hardware functionality to support missile C4I applications, such as information (data, image, video) compression and transmission. Adaptive and Reconfigurable Computers can adapt to the processing requirements of the application. The most advanced adaptive and reconfigurable computing systems are in-field, as well as in-mission, hardware adaptable processing architectures. Adaptive and Reconfigurable Computers have both fine-grained architectures based on Field Programmable Gate Array logic and coarse-grained architectures such as multiple processor elements on a chip with a reconfigurable interconnect fabric. As technology advances, these computers will have various combinations of microprocessors, memory structures, interface elements, digital signal processing elements, and programmable logic either on a single chip or on a circuit card. Technologies of interest include architectures, hardware developments, programming (configuration) environments, and C4I applications/demonstrations.

PHASE I: Select missile C4I applications which can benefit from adaptive, reconfigurable technologies and define the C4I demonstration. Survey Adaptive and Reconfigurable architectures and choose a development platform (hardware and software) for Phase II. Phase I may include a conceptual demonstration. Develop a Phase II development and demonstration plan.

PHASE II: Develop and demonstrate significant advancements in Reconfigurable Computing for missile C4I applications. Develop Phase III commercialization plan and strategy.

PHASE III: Commercialization and transition/transfer of developed products to the military and commercial markets. Potential applications in Signal and Image Compression & Transmission, and Information Fusion.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Reconfigurable Computing technology can be applied to any military or commercial system requiring image/video processing and compression.

REFERENCES:

- What is Reconfigurable Computing?, http://pw1.netcom.com/~optmagic/reconfigure/whatisrc.html
- Memon, N., and R. Anasari. Handbook of Image & Video Processing. Academic Press, 2000.
- Xilinx Digital Video web page & Related Features web pages: http://www.xilinx.com/esp/dvt.htm

KEYWORDS: Reconfigurable Computing, Adaptive Computing Systems, Image Compression, C4I, Field Programmable Gate Array, Hardware Software Co-Design

MDA04-47 TITLE: Execution of High Level Specifications for Simulation Based Acquisition

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS - MDA/BC (Battle Management/Command and Control)

OBJECTIVE: Provide innovative tools and techniques to enable development of specifications in logic - lightweight software formalisms

DESCRIPTION: The integration of Missile Defense elements and components into a cohesive Ballistic Missile Defense System (BMDS) requires extensive software development, deployment, and sustainment. New software specification development processes to utilize lightweight software formalisms for defining logic, coupled with

UML and other object oriented techniques, would greatly benefit the capability to develop the BMDS software lowering risk, including the re-engineering costs associated with obsolescence. The ability to utilize lightweight software formalisms for specification of a large, complex system is vital to controlling overall system cost and development risks. A mechanism for entering, executing, and analyzing system requirements using logic and key, emerging software formalism technology, is needed to support the up-front decision making capability for cost-effective acquisition. .

PHASE I: Determine the needs of a lightweight software formalism, logic based methodology. Define requirements specification tool and notation, and perform a feasibility study to determine that such trade studies can be executed on high level requirements early in the design process. This feasibility study may include a conceptual demonstration.

PHASE II: Implement a prototype version of the requirements specification/execution process. This shall be demonstrated by performing a series of trade studies on an example requirements specification of interest to the government.

PHASE III: Demonstrate a new lightweight software formalism logic process technology, and near-term application to the BMDS integrating element system software development process. This pilot project shall also verify the potential for enhancement of quality, reliability, performance and reduction of unit cost or total ownership cost of the proposed subject.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed work will be useful in any circumstance where the execution of a software driven specification can lead to early trade-off analyses in design. The applications of this technology could potentially be far reaching with large market potential.

REFERENCES:
Barr, P.C., Bernstein, A.R., Hamrick, M. Nicholson, D., Pawlowski, T., Ring, S.: "Executable Architecture for the First Digitized Division," Proceedings of SPIE, Vol. 4037, Digitization of the Battlespace V and Battlefield Biomedical Technologies II, 26-27, April 2000.

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Fitzhugh, Gary and Richard Comfort: "Obsolescence Solutions: Compatible Processor Upgrades and System Level Virtual Prototyping," Diminishing Manufacturing Sources
and Material Shortages Conference. April 1998.

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Military Implementation," Acquisition Review Quarterly, Spring-Summer 2001.

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Drusinsky, Doron and Shing, Man-Tak, Verification of Timing Properties in Rapid System Prototyping, Proceedings of Rapid System Prototyping Conference 2003.

Shaw, Mary and Garlan, David, Formulations and Formalisms in Software Architecture, Lecture Notes in Computer Science, Computer Science Today: Recent Trends and Developments, Jan van Leeuwen (Ed), Springer-Verlag 1996.

Drusinsky, Doron, Specs Can Handle Exceptions, Embedded Developers Journal, November 2001.

Rodion M. Podorozhny and Leon J. Osterweil, The Criticality of Modeling Formalisms in Software Design Method Comparison, Proceedings of the Nineteenth International Conference on Software Engineering, May 1997, Boston, MA.

Gluch, David P., et al, Model-Based Verification -- Scope, Formalisms, and Perspective Guidelines, Software Engineering Institute Report, CMU/SEI-2001-TN-024.

Vinu, George and Vaughn, Rayford, Application of Lightweight Formal Methods in Requirements Engineering, Crosstalk Magazine, January 2003.

KEYWORDS: Obsolescence; Re-engineering; Executable Specifications; High Level Languages; Requirements Analysis; Trade-off Analysis

MDA04-48 TITLE: Reconfigurable Analog Electronics for Missiles Defense Elements

TECHNOLOGY AREAS: Information Systems, Battlespace

ACQUISITION PROGRAM: BMDS - MDA/BC (Battle Management/Command and Control)

OBJECTIVE: Achieve dramatic reduction in the size and weight of seeker electronics while dramatically reducing time to deploy new sensor concepts into seeker implementations through reconfigurable, "pre-digital" electronics.

DESCRIPTION: Great strides have been made both in the miniaturization of complex electronics (through advanced packaging) and in their flexibility through the use of reconfigurable architecture concepts. The reconfigurable technologies, which include "configure-on-demand" (throughout a mission, for example) processors based on multiple field programmable gate arrays (FPGAs) and high-speed switch/link fabrics (such as Myrinet, Spacewire, and RapidIO), have been successfully demonstrated in multi-sensor applications (see references). These approaches, however, are digital, which creates a substantial barrier to further improvements in the miniaturization and flexibility of seeker electronics. It is well known, for example, that electronics packaging is very efficient for digital components, but that for the larger quantities of diverse passive and custom integrated circuit components often used in analog front ends, the compression is quite modest. Furthermore, the components are in usually fixed arrangements, and reconfiguration is not an option. As such, each and every sensor type and combination requires "hand-crafted" custom designs, which are bulkier and costlier than the digital backends (post analog conversion), which are far more programmable and flexible.

We believe it is possible to change this situation with flexible analog architectures, which can at least within the restricted domain of focal plane arrays and perhaps ladars and/or radars can be made flexible enough to support a great diversity of designs by simply reprogramming gains, offsets, filter characteristics, and other analog-domain topological and parametric constraints through software-only modification, thereby eliminating the expense and time associated with customized front ends. A prospective class of analog architectures that support reconfigurability within system are sought, which can be readily and compactly merged with the companion digital portions of an architecture to create a software-definable seeker system. In principle, such a seeker could be rapidly reconfigured to accommodate the attachment of new, more advanced seekers with less retrofit burden and more rapidly. The approach is extensible to other parts of the seeker system, to include mirror control, cryocoolers (if applicable), propulsion, and telemetry interfaces. The approach may be attractive not only to tactical missiles and interceptors, but also to UAV/UCAV platforms.

PHASE I: Offerors propose an analog architecture and demonstrate its feasibility through a combination of analysis, modeling/simulation, and breadboard constructions. Phase I proposals should demonstrate the widest range of applicability (for example, a variety of different focal plane arrays, including multicolor and odd pixel formats). Attention should be paid not only to the flexibility, but also to the means by which reconfiguration is initiated and managed.

PHASE II: Offeror must construct a prototype and demonstrate its ability to configure through software only using at least three different focal plane arrays. The approaches that can achieve plug-and-play or near plug-and-play with the smallest number of external (glue) components are believed to represent the best of the possible classes of implementation.

PHASE III: Commercialization and technology transfer opportunities are to be identified and a market strategy developed. Partnerships with other companies doing both government and commercial work are sought to exploit the unique reprogrammability features that this architecture will demonstrate.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The market potential is believed to be small but worthwhile, to include analog imaging, instrumentation, with potential extension audio/power domains, opening up a wide range of interesting configurable consumer products.

REFERENCES:

- What is Reconfigurable Computing?, http://pw1.netcom.com/~optmagic/reconfigure/whatisrc.html

- Memon, N., and R. Anasari. Handbook of Image & Video Processing. Academic Press, 2000.

- Xilinx Digital Video web page & Related Features web pages: http://www.xilinx.com/esp/dvt.htm

- Rooks, J., Lyke, J.; and Linderman, R. "Wafer Scale Signal Processors and Reconfigurable Processors in a 3-Dimensional Package", GOMAC 2002 Digest of Papers.

- Paul LeVan, James Lyke, James R. Waterman, James R. Duffey, and Brandon Paulsen. "The Passive Sensor Subsystem for DITP - Current Status and Projected Performance", 2001 IEEE Aerospace Conference Proceedings (Big Sky, Montana, 10-17 March 2001).

- P. McGuirk, J.C. Lyke, G.W. Donohoe "Malleable Signal Processor: A General-purpose Module for Sensor Integration", Military Applications of Programmable Logic Devices (MAPLD) 2000, Sept. 26-28, 2000.

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KEYWORDS: Reconfigurable Computing, Adaptive Computing Systems, Image Compression, C4I, Field Programmable Gate Array, Hardware Software Co-Design.

MDA04-49 TITLE: Multi-Frequency Radar Discrimination

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: BMDS - MDA/AB (Aegis Ballistic Missile Defense Program Office)

OBJECTIVE: Develop radar discrimination techniques that exploit frequency diversity. Of particular interest are techniques exploiting features measurable using S-band data.

DESCRIPTION:
The Aegis Ballistic Missile Defense Program Office anticipates the development of an S- and X-Band radar sensor suite as part of future missile defense capabilities. Both the S- and the X-band radars will support ballistic missile defense and the objective of this topic is to investigate the discrimination capability of the radar suite and particularly the contribution of the S-band sensor. Successful proposals will investigate the capability provided by the S-Band radar and/or the combination of the S- and X-band radar data.

PHASE I: Develop and conduct proof-of-concept demonstrations using simulated and/or real radar data. Identify exploitable features using S-band data alone or in combination with X-band data.

PHASE II: Refine concept(s) developed in phase I to allow near real time demonstration. Evaluate the proposed algorithms in an environment of intentional and unintentional countermeasures, noise and clutter.

PHASE III: Integrate the algorithms into a real-time signal processor for demonstration during live-fire and hardware in the loop evaluations.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technology is applicable to robotic systems, earth sciences, weather science, biometrics, transportation systems, and industrial applications requiring process monitoring by multiple-sensors.

REFERENCES:

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3. M. Skolnik, “Radar Handbook”, McGraw-Hill Publishing Co. (1990).
4. B. Edde, “Radar Principals, Technology, Applications”, Prentice Hall (1995).
5. S. Kay, “Fundamentals of statistical signal processing”, Prentice Hall (1998)
6. D. Manolakis, et el, “Statistical and adaptive signal processing: spectral estimation, signal modeling, adaptive filtering and array processing”, McGraw-Hill, 2000

KEYWORDS: Waveform, Multi-band RF Discrimination, Narrowband, Wideband, discrimination, S-band

MDA04-50 TITLE: Multiple Beam Klystron Electron Gun for Radar Applications

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: BMDS - MDA/AB (Aegis Ballistic Missile Defense Program Office)

OBJECTIVE: The multiple-beam Klystron (MBK) has been identified as a candidate high power amplifier technology supporting future radar system power and bandwidth requirements. Key to MBK performance is the multiple beam electron gun, which must support demanding reliability requirements as well as support a range of pulse repetition frequencies. The objective of this topic is to support research leading to new and innovative designs for MBK electron guns in an S-band amplifier that can support the high pulse repetition-rates and fast pulse rise-/fall-times required by advanced search and tracking radar waveforms, while minimizing voltage stresses to enhance system lifetime. Research or research and development efforts selected under this topic shall demonstrate and involve a degree of technical risk where the technical feasibility of the proposed work has not been established.

DESCRIPTION: MBKs are an RF amplifier technology with the potential to provide the high peak and average power performance necessary for BMD applications combined with the low phase noise required by Naval radar applications. The specific goal is to demonstrate a pulsed multiple-beam electron gun (>20 parallel beamlets), beam optics, and beam transport system capable of generating and propagating an electron beam with a peak power of ~1.6 MW with a minimum of beam interception. The gun must be capable of supporting pulse repetition frequencies (PRFs) between 200 to 3000 Hz with pulse rise- and fall-times of less than 100 ns; the maximum pulse duration is 100 microseconds (consistent with a maximum duty factor of 4%). The beam must be fully turned-off between pulses. To minimize high voltage stress, the beam control voltage should not exceed 10 kV, requiring the use of a grid- or control-electrode. The ultimate goal is to integrate the gun with an S-band MBK.

PHASE I: Complete an detailed mechanical, electromagnetic, and thermal design of a multiple-beam electron gun using 3-D mechanical and electromagnetic design. Develop the specification requirements for a solid-state high voltage power supply-modulator system consistent with gun performance requirements described above.

PHASE II: Using the gun design results of Phase I, fabricate a pulsed multiple-beam gun and beam transport system. Experimentally demonstrate that the pulsed performance of the system meets the required specifications with minimal beam interception (>95% beam transmission).

PHASE III: Integrate the pulsed multiple-beam gun into a high average power MBK with a performance that is consistent with an AN/SPY-1 relevant transmitter system. Develop a production system for radar applications. Transition to commercial markets and non-SBIR funded status through the sale of derivative proof of concept units to private corporations and government agencies who own, operate or maintain the AN/SPY-1 radar systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Commercial applications of multiple-beam amplifier technology include broadband high-power amplifiers for commercial satellite up-links and high-energy accelerators, where the low operating voltage is attractive due to reduced costs and increased reliability.

REFERENCES:
1. E.A. Gelvich, et al, "The new generation of high-power multiple-beam klystrons," IEEE MTT Transactions, 41, pp.15-19 (1993).
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5. K.T. Nguyen, D. Pershing, J. Pasour and J. Petillo "Multiple-beam electron gun development for high-power amplifiers", 3rd IEEE Int. Vacuum Electronics Conference, IVEC 2002, April 23-25, Monterey, CA USA, 02EX524.

KEYWORDS: Multiple-beam klystron, MBK, multiple-beam electron gun, multiple-beam amplifier, radar, transmitter

MDA04-51 TITLE: Advanced Divert and Attitude Control Systems (DACS)

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: BMDS - MDA/TH (THAAD)

OBJECTIVE: The objective of this research and development effort is to develop innovative high performance component technologies that will enhance the capability of divert and attitude control systems(DACS).

DESCRIPTION: Improved DACS technology is needed to address insensitive munitions and safety requirements, while maximizing the kill vehicle (KV) divert capability and/or reducing the KV weight within restricted geometries. A host of interrelated technologies include low cost/high performance nozzle materials, non-toxic propellants, alternative pressurization schemes, etc. are of interest. The candidate DACS technologies should be lightweight (low density), have high fracture toughness, retain their strength at elevated temperatures, and resist to the propellant environment without supplemental oxidation protection. The innovative fabrication processes employed in the development of the advanced DACS should be able to fabricate complex shapes with rapid fabrication techniques at reduced manufacturing cost. Numerous candidates for fit, form and functional component replacements may be available in time to support a near term insertion opportunities.

PHASE I: Conduct experimental and analytical efforts to demonstrate proof-of-principle of the proposed technology to enhance DACS performance.

PHASE II: Demonstrate feasibility and engineering scale-up of proposed technology; identify and address technological hurdles. Demonstrate applicability to both selected military and commercial applications.

PHASE III: The developed technology has direct insertion potential into the THAAD system.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would have applicability to commercial space platforms, thermal protection materials and control surfaces, automobile components such as turbochargers, high temperature environment systems such as recuperators in melt furnaces, jet APU ring motors etc.

REFERENCES:
1. George T. Hutton, "Rocket Propulsion Elements; Introduction to the Engineering of Rockets" Seventh Edition, John Willey and Sons, 2001.

2. Vigor Yang, Thomas B. Brill, and Wu-Zhen Ren, "Solid Propellant Chemistry, Combustion, and Motor Interior Ballistics", AIAA, 2000.

KEYWORDS: interceptor kill vehicle, divert and attitude control, nozzle materials, propellant

MDA04-52 TITLE: Hypergolic Chemical Leak Detector

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: BMDS - MDA/TH (THAAD)

OBJECTIVE: Develop a detector, flush mounted on the outside of the missile canister, that would be capable of sensing leaks of hypergolic rocket fuels and oxiders.

DESCRIPTION: A number of currently used missile systems use hypergolic rocket fuels and oxidizers as a means of propulsion. A significant shortfall in this area is our inability to accurately verify any leaks present of the hypergolic fuels and determine that the system is operational. Consequently, this SBIR topic is focused on the development of a hypergolic chemical leak detector. This leak detector should be self powered with a battery that could last at least 10 years and the battery should be changeable from outside of the canister. The detector should have a data out-put port that could be tapped by a centralized data management system, for historical data. The detector should be flush mounted on the outside of the missile canister, be lightweight and occupy a minimum space. The detector should have a visible and audible alarm and have both an electronically discernable "test" mode as well as a manual push button type test mode. Typically, the detector should be checked just before missile canisters are loaded onto some means of transportation and again following offload. The key to the utility of this detector is NOT a low threshold for detection, but a programmable detection of a pre-set "rate of change" of the target contaminant. A true "leak" of significance should result in a fairly rapid change in the concentration of the target chemical inside the missile canister. Once a threshold for a selected rate of change has been reached, the alarm should sound. As a back-up the sensor should also sound an alert when a certain, relatively high, concentration of the contaminant has been reached, regardless of how long it took to get there. The chemicals the unit should be sensitive to include any of the common Hypergolic rocket fuels and oxidizers, to include Monomethyl Hydrazine, RFNA , MON-25, and others.

PHASE I: Conduct experimental efforts to demonstrate proof-of-principle of the proposed technology to detect and characterize leaks in the above mentioned fuel systems. Demonstrate the initial feasibility of the detector system.

PHASE II: Demonstrate feasibility and engineering scale-up of proposed technology; identify and address technological hurdles. Demonstrate applicability to both selected military and commercial applications.

PHASE III: The cost avoidance realized by the Ballistic Missile Defense System and the services by employing this technology would be significant. Hence, the anticipated Phase III program customers would include a wide range of current interceptor programs. During Phase III the effort calls for engineering and development, test and evaluation, and hardware qualification.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The proposed technology would be anticipated to have a high level of interest as a diagnostic tool in the area of explosives, commercial launch rocket propellants, etc.

REFERENCES:
1. P. Marteau, F. Adar, and N. Zanier-Szydolski, “Application of Remote Raman Measurements to the monitoring and Control of Chemical Processes,” American Laboratory, pp21H-21Q, Oct. 1996

KEYWORDS: Hypergolic, propellant, detector.

MDA04-53 TITLE: Advanced Seeker Technologies

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: BMDS - MDA/TH (THAAD)

OBJECTIVE: Develop advanced sensors and technologies to support multiband (IR and Visible) imagery for target detection and discrimination. This encompasses advanced window designs, multicolor infrared (IR) focal plane arrays, and imaging LADARs.

DESCRIPTION: Advanced seekers are required for enhanced target detection, on-board discrimination and improved end-game guidance for hit-to-kill interceptors used in missile defense systems. These on-board sensors must be compatible with the existing hardware. The specific technology areas to be investigated are advanced window designs, multicolor focal plane arrays (FPA), and Range-Resolved Doppler Imaging LADAR capabilities.

The optical windows used on a kill vehicle (KV) must be ruggedized to withstand this operational environment. The research tasks are to develop an optical window(s) that will provide extended MWIR, LWIR, LADAR, and multicolor sensor operation in a highly stressing environment. There is a need for a replacement for the existing sapphire window used for extended MWIR sensors with a longer-term need for the full optical range.

The multicolor FPA sensor technology will develop a single FPA design that will provide two, or more, colors at full resolution. This will replace the multiple FPAs currently required for multicolor optical seekers. The FPA should have MWIR/LWIR capability as well as provide good pixel-to-pixel uniformity and low readout noise while delivering a high quantum efficiency. There is also a need to develop a multicolor VLWIR FPA with similar performance.

The combination of a Range-Resolved Doppler Imaging LADAR with a multicolor IR seeker provides a three-dimensional imaging capability that will reduce or eliminate dependency on a priori data for target aimpoint selection. Technologies that enhance the beam quality, pulse repetition rate, efficiency and power of the LADAR are critical to the optimal performance of this technology.

PHASE I: Design, fabricate and provide proof-of-principle demonstrations of advanced seeker sensor technologies.

PHASE II: Develop prototype seeker systems and demonstrate these in a simulated flight environment. These tests should include environmental testing to ensure reliable operation in a stressing, realistic operational environment.

PHASE III: Integrate seeker technology into interceptor designs for incorporation in block upgrades.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: The sensor technologies being developed in this effort will have dual application in law enforcement and for material processing to detect material defects.

REFERENCE: "The Infrared & Electro-Optical Systems Handbook", J.S. Accetta and D.L. Shumaker, exec. eds., SPIE Optical Engineering Press, Bellingham, Washington, 1993.

KEYWORDS: Seeker, Multicolor Focal Plane Array, LADAR, MWIR, LWIR, VLWIR

MDA04-54 TITLE: Radar Data Fusion for Single Integrated Air Picture (SIAP)

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: BMDS - MDA/GM (Ground Based Midcourse)

OBJECTIVE: Develop algorithms, software, and/or hardware necessary to collect, process, and fuse information from multiple Radars (either at the same or different frequency) to form a single integrated air picture (SIAP).

DESCRIPTION: Timely fusion of data collected from a variety of Radars that acquire information from multiple perspectives and/or different frequencies, may provide a more accurate picture of the adversary threat cloud than any single Radar or group of Radars operating independently. Algorithms, software, and/or hardware that enable this synergistic fusion and interpretation of data from disparate GMD Radars should enhance system acquisition, tracking and discrimination of threat objects in a cluttered environment and provide enhanced battle space awareness. Fusion of data at several levels may be required. Technical issues that must be addressed include: spatial and temporal registration of Radars, data throughput within and between sensor platforms, processing speed and capacity, and sensor calibration.

PHASE I: Develop and conduct proof-of-principle demonstrations of advanced data fusion concepts using simulated sensor data.

PHASE II: Update/develop technology (algorithms, software, hardware, or a combination thereof) based on Phase I results and demonstrate technology in a realistic environment using data from multiple Radars. Demonstrate ability of technology to work in real-time in a high clutter environment.

PHASE III: Integrate technology into GMD system and demonstrate the total capability of the updated system. Partnership with traditional DOD prime-contractors will be pursued since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: The technology is applicable to air traffic control and weather.

REFERENCES:
1. Martinez, David, et.al., “Wideband Networked Sensors”, MIT Lincoln Labs, http://www.ngi-supernet.org/NGI-PI-2000/Martinez.PDF

KEYWORDS: Sensor Fusion; Data Fusion; Sensor Integration; Signal Processing; Algorithm; Multi-Sensor

MDA04-55 TITLE: Innovative Approaches to Increase Power And Efficiency in Components Based on GaN or Other Materials Offering Performance Enhancements Exceeding that of GaAs, in X-Band Radars.

TECHNOLOGY AREAS: Materials/Processes, Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: BMDS - MDA/GM (Ground Based Midcourse)

OBJECTIVE: Develop lithography/ circuit/ item placement/ design iterations leading to increased power and efficiency and/or decreased transmission line loss in high power components based on GaN, or other materials offering performance enhancements exceeding that of GaAs, destined for use in X-Band Radars.

DESCRIPTION: Most of the waste heat in a transceiver (Transmit/Receive or T/R) module is from the power output stage. With the introduction of power output stages fabricated from GaN or other wide bandgap semiconductor materials, there may be the possibility of lithography/ circuit/ item placement/ design iterations that could increase power and efficiency or decrease transmission line loss. (Goal): Decrease the amount of the hardware and logistics required to support large cooling systems currently needed for inefficient transceiver modules, reduce costs for implementing these large cooling systems and additionally provide more compact, reliable, efficient, powerful, low cost X-Band Radars and military/commercial power semiconductors. The current state of the art is represented in GaN and SiC based technology.

PHASE I: Develop and conduct proof-of-principle demonstrations of lithography/ circuit/ item placement/ design iterations that could increase power efficiency or decrease transmission line loss.

PHASE II: Update/develop technology based on Phase I results and demonstrate technology in a realistic environment.

PHASE III: Integrate technology into GMD system and demonstrate the total capability of the updated system. Partnership with traditional DOD prime-contractors will be pursued since the Government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: The technology is applicable in high power circuit design, radar and communications.

REFERENCES:

1. "Gallium Nitride & Related Wide Bandgap Materials And Devices" DARPAtech 2000 briefing by Dr. Edgar J. Martinez, http://www.darpa.mil/DARPATech2000/Presentations/mto_pdf/7MartinezGaNandRelatedWBGB&W.pdf

2. "Wide Bandgap Semiconductors for Utility Applications", Leon M. Tolbert, Burak Ozpineci, S. Kamrul Islam, and Madhu S. Chinthavali, University of Tennessee and Oak Ridge National Laboratory, 2003. http://powerelec.ece.utk.edu/pubs/iasted_2003_wide_bandgap.pdf

KEYWORDS: Lithography; circuit design; component placement; transceiver module; transmit and receive modules, power, efficiency; X-Band Radar, amplifiers, XBR; UEWR

MDA04-56 TITLE: Computer Network Operations (CNO)

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS - MDA/GM (Ground Based Midcourse)

OBJECTIVE: Develop and demonstrate innovative software and/or hardware solutions to the problem of Computer Network Operations (CNO) in the context of BMDS Program Protection Plans and associated architectures.

DESCRIPTION: Computer Network Operations (CNO) refers to defensive measures taken to protect and defend information, computers, and networks from disruption, denial, degradation, or destruction. Solutions should focus on applications of CNO situational awareness, advanced intelligent intrusion detection, trusted software and trusted computing base, vulnerability scanning, disaster prevention and recovery, secure infrastructure, malicious insider detection, and forensics as they relate specifically to missile defense systems and networks. Solutions should mitigate increased system latency or network response times. Solutions should be capable of working in cooperation with existing and planned methods and COTS products and be capable of integrating with agent based systems in a work-centered environment supporting the CNO manager. Knowledge-based systems and multi-agent systems are of particular interest since they are a natural fit for many CNO problems. As such systems are employed for CNO, it becomes critical that the agent platforms themselves be reliable and secure. Additionally, intelligent mechanisms are needed for capturing security expert knowledge during normal CNO security operations. For these knowledge-based systems to be effective, CNO systems must be able to utilize the knowledge captured and existing CNO software to intelligently protect and defend information, computers, and networks from attack.

PHASE I: Analyze, design, and conduct proof-of-principle demonstrations of methods for CNO application software systems that provide CNO services or hardware that contributes to CNO initiatives for missile defense systems.

PHASE II: Develop and demonstrate prototype platform/software/hardware that demonstrates advancement of CNO initiatives by illustrating functional effectiveness against predetermined and/or previously unseen cyber threat sets.

PHASE III: Prepare detailed plans for and implement demonstrated capabilities on critical military and commercial applications.

PRIVATE SECTOR COMMERCIAL APPLICATIONS: Advanced CNO software/hardware has application throughout commercial industries. Commercial systems that are exposed to internet and corporate intranets would benefit greatly from this development. In addition to military and homeland defense, banking, finance, e-commerce, and medical industries would have a high demand for such systems.

REFERENCES:
1. Smith, Andrew, “Digging for Worms, Fishing for Answers,” Purdue University, December 2002.
2. Spafford, Eugene and Crosbie, Mark, “An Architecture for Intrusion Detection using Autonomous Agents,” Purdue University, 11 June 1998.
3. Spafford, Eugene and Crosbie, Mark, “Active Defense of A Computer System Using Autonomous Agents,” Purdue University, Feb 15, 1997.

KEYWORDS: computer network attack, computer network defense, computer security, agent based systems, intrusion detection

MDA04-57 TITLE: Electronic Techniques For Radiation Hardening of EKV Electro-Optics Subsystems

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: BMDS - MDA/GM (Ground Based Midcourse)

OBJECTIVE: Develop innovative electronic hardening concepts and technologies for current and next generation multi-color LWIR and VLWIR detectors, ROICs, and sensor-associated avionics for application to GMD EKV.

DESCRIPTION: In order to improve the GMD missile seeker¡¦s capability to detect and discriminate threat objects at greater ranges, detectors with increased sensitivity must be employed along with higher performance avionics. These systems must function reliably when exposed to background radiation from space and radiation resulting from nuclear events (including prompt and persistent gamma, single event effects, total ionizing dose, space radiation, etc.). In addition, systems must survive and function after prolonged periods in battlefield/storage environments (Shock, vibrations, thermal, etc). Current designs rely on Commercial-Off-the-Shelf (COTS) technology. Optimal utilization of mass in a lightweight EKV precludes exclusive reliance on shielding as a means of countering the adverse effects of radiation, consequently, inherently radiation-resistant component, systems, and usage techniques are imperative. Particular emphasis should be placed on hardening Read Out ICs (ROIC) supporting low temperature Focal Plane Arrays (FPAs) and multi-color FPAs designed to function at VLWIR (> 14 mm) and/or LWIR (7 to 14 mm). The Focal Plane assembly considered may include an optical filter that has to be radiation hard. Readout electronics may be 3-Dimensional since multicolor FPA architecture may use a stacked multi-layer approach.

PHASE I: Conduct research and experimental efforts to demonstrate proof-of-principle of the proposed concepts. Determine feasibility of automated radiation hardening design tools, in conjunction with rad hard foundries, to make system electronics designs, including commercial designs, portable among foundries.

PHASE II: Demonstrate feasibility of proposed concept/technology; identify and address technological hurdles; Finalize Phase I design and develop a prototype component. Demonstrate applicability to both selected military and commercial applications.

PHASE III: Due to current high levels of interest of this technology in both government and industry related to ground and space based applications, there are many opportunities for the advancement of this technology during phase III program. Partnership with traditional DOD prime-contractors will be pursued since the government applications will receive immediate benefit from a successful program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Supporting instruments can be used in a wide variety of commercial environmental/remote sensing monitoring systems and Space surveillance, weather satellites.

REFERENCES:
1. F.T.Brady, J.Maimon, and M.Hurt ¡§A Scalable, Radiation Hardened Shallow Trench Isolation,¡¨ IEEE Transactions on Nuclear Science December 1999.
2. R.C.Lacoe, J.V.Osborn, D.C.Mayer, S. Witczak, S.Brown, R.Robertson, and D.R. Hunt, ¡§Total-Dose Tolerance of
Chartered Semiconductor 0.35 ƒÝm CMOS Process,¡¨ IEEE Transactions on Nuclear Science December 1999.
3. P.E.Dodd, M.R.Shaneyfelt, E.Fuller, J.C. Pickel, F.W.Sexon, and P.S.Winoker, ¡§ Impact of Substrate Thickness on Single-Event Effects in Integrated Circuits,¡¨ IEEE Transactions of Nuclear Science Vol 48, No.6. December 2001.
4. Y.Li, G.Niu, J.D. Cressler, J.Patel, et al, ¡§Anomalous Radiation Effects in Fully Depleted SOI MOSFETs Fabricated on SIMOX,¡¨ IEEE Transactions of Nuclear Science Vol 48, No. 6. 2146, December 2001.
5. J.P. Colinge, ¡§ Silicon-on-Insulator: materials to VLSI¡¨, Kluwer Academic Publishers (1991).
6. M.J.Tostanoski, J.Nonnast, R.E.Strayer,Jr. R. Goldflam, and J.R.Henley ¡§ Gamma Radiation Test Results From a 64x64 HgCdTe Medium Wave Infrared Focal Plane Array¡¨ Heart Conference 1997.
7. J.B.Hill, N.J.Redmond, W.B.Margopoulos, L.J.Gunther, J.Florian, C.E.Mallon, P.R.Mackin, and A. Andrews,¡¨ Pulsed Gamma/Beta Noise effects on Interceptor System target selection¡¨ Heart Conference 1997.

KEYWORDS: Transient radiation; mitigation; Photo-detectors; In-pixel; FPA; Simulation; miniaturize; sensors; Proton; Neutron; single event effects; hardened electronics; hardened MEMS

MDA04-58 TITLE: Advanced Divert and Attitude Control (DACS) system for the Miniature Kill Vehicle (MKV)

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: BMDS - MDA/GM (Ground Based Midcourse), MDA/AS (Advanced Systems)

OBJECTIVE: Develop a low weight, small volume, high performance DACS system that could be incorporated into a Miniature Kill Vehicle which weights less than 2 kg, and has a volume of less than 3,000 cubic cm.

DESCRIPTION: Miniature interceptors, especially an integrated version of them launched from a single booster that could intercept multiple objects in the exo-atmosphere, have the potential to solve many difficult countermeasure problems, such as antisimulation, submunitions, encapsulated reentry vehicles (RVs) etc. Miniature interceptors weighing less than 2.0 kilograms and costing less than $50 K are desired. Developing a DACS system that can meet weight, volume, cost and performance for such an interceptor requires new innovative technologies. Divert performance of better than 500 m/sec, with high mass fraction capability and time constant of a few milliseconds is desired. At the same time the DACS system should produce low vibration, shock and jitter that would effect the seeker operation in a minimal way. Since the kill vehicle is very small and requires hit-to-kill guidance accuracy, the proposed DACS system should pay special attention to effects on seeker stabilization and propose approaches and technologies to mitigate these effects. The system will also need to meet the insensitive munitions storage and transportation requirements. Therefore substantial latitude is left to interested firms in proposing advanced DACS concepts and technologies that could be applied to meet these needs.

PHASE I: Identify proposed technology. Conduct analytical and experimental efforts to demonstrate proof-of-principle and establish basic performance criteria and areas for further refinement in Phase II.

PHASE II: Demonstrate feasibility and engineering scale-up of proposed technology. Fabricate a prototype that demonstrates capabilities defined during Phase I and demonstrate the technology in a laboratory environment and with field tests.

PHASE III: The developed technology has direct insertion potential into missile defense systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technologies developed under this SBIR topic would have applicability to micro vehicles, unmanned vehicles, small munitions, automobile industry etc.

REFERENCES:
1. Paschal N., Strickland B., Lianos D., " Miniature Kill Vehicle Program", 11th Annual AIAA/BMDO Technology Conference, Monterey, CA, August 2002.
2. Lianos D., Strickland B., " A midcourse Multiple Kill Vehicle Defense Against Submunitions", 6th Annual AIAA/BMDO Technology Readiness Conference, San Diego, CA, August 1997.

KEYWORDS: interceptor; guidance; sensor; MEMS; power sources

MDA04-59 TITLE: Define/Demonstrate Non-hazardous or Less Hazardous Beryllium (Be) Material for Defense Applications

TECHNOLOGY AREAS: Sensors, Electronics, Battlespace

ACQUISITION PROGRAM: BMDS - MDA/GM (Ground Based Midcourse)

OBJECTIVE: Develop an innovative method to minimize or eliminate the health hazards and/or toxicity associated with manufacturing Be components for use in numerous Defense applications.

DESCRIPTION: As an industrial material, Be/Be alloy possesses some uncommon qualities such as its ability to withstand extreme heat, remain stable over a wide range of temperatures and function as an exceptional thermal conductor. These characteristics have made it a unique material suitable for a host of diverse, demanding applications. Be/Be alloy structures, including sensor mirrors, are used in a wide range of military/defense applications. It has been the material of choice for many applications due to its desirable characteristics despite health hazard concerns associated with material handling and per unit cost. The health hazard concerns are becoming increasingly more visible and it is projected that Be/Be alloy structures may become virtually unobtainable in the next decade. In the last few years, a significant effort has been made to find substitute materials but the challenge has been to find a material that fulfills all of the desirable, or least the most critical, Be/Be alloy properties without any substantial trade off in its (Be) desirable performance characteristics.

PHASE I: Investigate suitable Be/Be alloy substitute materials. Develop a matrix to do a comparison of desirable properties, cost per unit, producibility characteristics and availability. Primary desirable characteristics include but are not limited to: light weight (Be is one of the lightest of all metals), high melting point, rigidity (stiffness), dimensional stability over a wide range of temperatures, hardness, high tensile strength, resistance to corrosion from acids, fatigue resistance, nonmagnetic properties, and electrical and thermal conductivity.

PHASE II: With the successful completion of Phase I, down select one to three candidate materials and prototype production representative structure(s) for qualification-type testing. The prototype structures will be selected based on the most desirable Be/Be alloy characteristics that can be demonstrated in testing scenarios. Input from prime contractors will be solicited to assist in determination of most desirable property characteristics to demonstrate. However, at this juncture it appears that rigidity, lightweight, high tensile strength, dimensional stability over a wide range of temperature and fatigue resistance are the more desirable characteristics to be tested. Once the test parameters are selected, a test plan will be developed to demonstrate the desired properties. The prototype structure, possibly to scale, will be fabricated and the testing will occur. Test results will be documented so that performance can be compared to Be/Be alloy structure performance. These results will be available to interested commercialization partners.

PHASE III: Successful completion of Phase II will result in a demonstrated/validated production representative prototype component that can serve as the basis of the migration to more acceptable (from the health hazard perspective) material solution for candidate weapon system. It is anticipated that the cognizant prime contractor will welcome the opportunity to partner with the proven substitute material provider.

PRIVATE SECTOR COMMERICAL POTENTIAL: The use of beryllium, as an alloy, metal and oxide, in electronic and electrical components, and in aerospace and defense applications accounted for an estimated 80% of the total 2000 US consumption. Beryllium and beryllium alloys are used as base metal in battery contacts and electronic connectors in cell phones and base stations. Beryllium-Copper alloys are often the only material that meets the need for high reliability and miniaturization in these applications as well as being used as castings in the aerospace industry. FM radio, high-definition and cable television and underwater fiber optic cable systems also depend on beryllium. Beryllium metal is used principally in aerospace and defense applications, such as surveillance satellite and space vehicle structures, inertial guidance systems, military aircraft brakes and space optical system components. Military electronic targeting and infrared countermeasure systems use beryllium components, as do radar navigation systems. Beryllium is also a staple material in Apache helicopters, fighter aircraft and tanks, and aircraft landing gear components. In the US space shuttles, several structural parts and brake components use metallic beryllium. Beryllium oxide is an excellent heat conductor and acts as an electrical insulator in some applications. However, beryllium oxide serves mainly as a substrate for high-density electronic circuits for high-speed computers, and automotive ignition systems. The medical profession relies on beryllium for applications in pacemakers and lasers to analyze blood for HIV and other diseases and for X-ray windows since it is transparent to X-rays. The uses for Be/Be alloys spans an enormous range of commercial as well as defense applications and the commercial potential for a substitute material is virtually incalculable.

REFERENCES:
1. Bever, Michael B., Encyclopedia of Materials Science and Engineering, Vol. 1, Pergamon Press Ltd., pgs. 289-300, 1986.
2. Brady, George S., Clauser, Henry R. and Vaccari, John A., Materials Handbook: An Encyclopedia for Managers, Technical Professionals, Purchasing and Production Managers, Technicians, and Supervisors, McGraw-Hill, pgs. 105-111, 2002.
3. Lewis, Richard J. Sr., Sax's Dangerous Properties of Industrial Materials, Ninth Edition, Van Nostrand Reinhold, New York, pgs 389, 391-392, 1996.
4. Occupational Exposure to Beryllium, Request for Information, Federal Register 67:70707-70712, November 26, 2002, http://www.osha.gov/SLTC/beryllium/index.html
5. Preventing Adverse Health Effects From Exposure to Beryllium on the Job, U.S. Department of Labor, Occupational Safety & Health Administration Hazard Information Bulletins, dated September 02, 1999.
6. Report on Carcinogens, Tenth Edition; U.S. Department of Health and Human Services, Public Health Service, National Toxicology Program, December 2002, http://ehp.niehs.nih.gov/
roc/tenth/profiles/s022bery.pdf
7. Yoshida, Tsutomu, et al., A study on the Beryllium Lymphocyte Transformation Test and the Beryllium Levels in the Working Place, National Institute of Industrial Health, 1997 Vol. 35, pgs 374-379, http://www.niih.go.jp/en/indu_hel/1997/1997_45.htm

KEYWORDS: Beryllium; stiffness; hardness; strong; stable; fatigue-resistance

MDA04-60 TITLE: Performance Enhancement of In-Flight Interceptor Communications System (IFICS)

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS - MDA/GM (Ground Based Midcourse)

OBJECTIVE: Increase probability of message delivery by In-Flight Interceptor Communication System (IFICS) under adverse conditions by utilizing innovative algorithms, implemented in software and/or application specific integrated circuits, to enhance system performance and reliability.

DESCRIPTION: It is essential that the IFICS function in nuclear and jamming environments. Recent developments in coding theory, particularly Turbo Codes, may lead to significant improvements in link performance. Particular emphasis is placed on optimizing error detection/correction algorithms in Rayleigh and Rician fading channel conditions, as produced by nuclear weapons effects in the ionosphere. Software and/or application specific integrated circuits may be used to implement algorithms

PHASE I: Conduct research and experimental efforts to demonstrate proof-of-principle of the proposed technology. Measure and report performance improvements over current state-of-the-art.

PHASE II: Demonstrate flight readiness of technology. Fabricate and test prototype hardware/software. Demonstrate applicability to both selected military and commercial applications.

PHASE III: Insert this technology into future Ballistic Missile Defense systems such as the GMD interceptor. Adapt this technology to commercial markets.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technology may have commercial and industrial application in remote operations and airline communications.

REFERENCES:

1. Performance Evaluation of Superorthogonal Turbo Codes in AWGN and Flat Rayleigh Fading Channels by Petri Komulainen and Kari Pehkonen, IEEE Journal on Selected Areas in Communications, Vol. 16, No. 2 Feb. 1998.
2. A Conceptual Framework for Understanding Turbo Codes, by Gerard Battail, IEEE Journal on Selected Areas in Communications, Vol. 16, No. 2 Feb. 1998.

KEYWORDS: error correction; error detection; missile communications; turbo codes; fading channels

MDA04-61 TITLE: Infrared (IR) Multispectral Imager for the Next Generation EKV

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: BMDS - MDA/GM (Ground Based Midcourse)

OBJECTIVE: Develop a multispectral (ten or more adjacent spectral bands) imager that will assist in the mid-course discrimination function of the Exo-atmospheric Kill Vehicle (EKV) by providing infrared spectral signatures and temperature measurements of remote objects within the threat cloud.

DESCRIPTION: One approach to the acquisition, tracking and determination of the temperature of objects in space by remote sensing is to use two Long Wavelength Infrared (LWIR) Focal Plane Arrays (FPAs), filters and beam splitter, Read Out Integrated Circuits (ROICs) and cryogenic cooling lines to both FPAs. Problems with spatial co-registration of targets, sensor calibration, and the additional cooling requirements, which result from this approach, complicate system design, reduce system reliability and limit the temperature measurement to objects having graybody spectral characteristics. An alternate approach involves the use of a single, one-color, Very Long Wavelength Infrared (VLWIR) FPA with high pixel uniformity, reduced readout noise, improved resolution and operability. When this FPA is positioned behind a scanning spectral filter system such as a Fabry-Perot interferometer it would permit an interceptor missile seeker to acquire, track, and discriminate colder objects by obtaining their spectral surface characteristics as well as the temperature of gray- and, more importantly, non-graybody objects. SBIR proposals are solicited that address the development of the latter concept or developments of subsystem components, such as for example the development of a compact, low-weight, non-mechanical (i.e., no moving parts) spectral filter. In general, the SBIR proposal should address one or all of the following topics: 1) Design/development/ research of a robust, small volume, low-mass multispectral (10 – 20 spectral bands) imager. 2) Development of a compact, spectral scanning filter system for the LWIR band which is applicable to an imaging system; and 3) development of innovative non-mechanical techniques for rapid (approx. 1000 Hz) tuning of an LWIR spectral filter.

PHASE I: Conduct research and experimental efforts to demonstrate proof-of-principle of the proposed technology. Measure and report performance improvements over current state-of-the-art.

PHASE II: Demonstrate flight readiness of technology. Fabricate and test prototype hardware/software. Demonstrate applicability to both selected military and commercial applications.

PHASE III: Insert this technology into future Ballistic Missile Defense systems such as the GMD interceptor. Adapt this technology to commercial markets.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The technology may have commercial and industrial application in remote sensing operations, weather and atmospheric science.

REFERENCES:
1. Cooke, B. J., Laubscher, B. E., and Bore1, C. C., "Methodology for Rapid Infrared Multi-Spectral, Electra-Optical Imaging System Performance Analysis and Synthesis", Proc. SPIE Vol. 2743, pp. 52-86, June 1996. http://nis-www.lanl.gov/~borel/SPIE2743.pdf
2. Bakker, E. J., Schwering, P. B. W., and van den Broek, S. P., "From hyperspectral imaging to dedicated sensors," Proc. SPIE Vol. 4029, pp 312-323, July 2000. http://www.strw.leidenuniv.nl/~bakker/publications/pdf_files/SPIE2000_4029_37.pdf
3. Sofya Poger and Elli Angelopoulou, Selecting Components for Building Multispectral Sensors. http://www.cs.stevens-tech.edu/~elli/cvpr01.sketch.pdf
4. Anderson, R., Malila, W., Maxwell, R., and Reed, L.,"Military Utility of Multispectral and Hyperspectral Sensors," Infrared Information Analysis Center (ERIM), Nov. 1994.

KEYWORDS: Infrared sensing; Multispectral imaging; Tunable filters; Fabry-Perot devices; Infrared spectral emissivity

MDA04-62 TITLE: Electronically Steerable IFICS Data Terminal Antennas

TECHNOLOGY AREAS: Electronics

ACQUISITION PROGRAM: BMDS - MDA/GMB (GFC/C Program Office)

OBJECTIVE: Develop electronically steerable antennas for ground to space vehicle communication systems with characteristics necessary for the missile defense application.

DESCRIPTION: Current IFICS Data Terminal (IDTs, ground stations) communications antennas are based on dish structures, which need to be pointed rapidly. The need for physical pointing is a constraint on communications availability and performance. Electronically steerable antennas would reduce the need for antenna repositioning allowing more rapid and frequent communication events. The ground based antenna should be capable of receiving and transmitting in a half-duplex fashion in the 20 to 22 GHz range for up and down links. The ground system needs to be capable of high power transmission, rapid steering, provide narrow beamwidths (~ 3 degrees or less), and low noise temperatures.

PHASE I: Develop a conceptual design for a ground based electronically steerable antenna suitable for interceptor communications. Perform modeling and simulation using commercially accepted tools to validate proposed designs and predict performance.

PHASE II: Develop and test a proposed concept design for a ground vehicle antenna.

PHASE III: Develop designs for P3I enhancements to the Ground Based Midcourse Defense Segment of Missile Defense and potential application to new systems being developed for boost and terminal phases.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Additional applications would be numerous military and commercial satellite communication systems.

REFERENCES:
1. Hanson, R. C., Phased Array Antennas, Wiley - Interscience, 1997.
2. Fourikis, Nicholas, Phased Array Based Systems and Applications, John Wiley and Sons, 1997.

KEYWORDS: Antennas; Electronically; Steerable; Rapid; Ground; Space

MDA04-63 TITLE: Electronically Steerable Antenna for Kill Vehicle and Space Platforms

TECHNOLOGY AREAS: Sensors, Electronics

ACQUISITION PROGRAM: BMDS - MDA/GMB (GFC/C Program Office)

OBJECTIVE: Develop electronically steerable antennas for use in space vehicle communication systems including the technical characteristics necessary for the missile defense application.

DESCRIPTION: Current Ground based Missile Defense (GMD) Kill Vehicle (KV) communications antennas are based on a fixed array, which must be pointed by reorienting the KV. The need for physical pointing is a constraint on communications availability and performance. Physical aiming of the antenna using a movable mount is undesirable since that affects KV mass distribution. Electronically steerable antennas would reduce the need for KV reorientation allowing more rapid and frequent communication events. A KV is extremely constrained on size, weight and power (current GMD KV is around 18"long, antennas are around 6x6x0.5 inches and weigh less than 5 oz.). It must endure very high acceleration (50+Gs) and significant vibration during launch. The space based antenna needs to be small, lightweight, efficient, capable of receiving and transmitting in a half-duplex fashion in the 20 to 22 GHz range for up and down links. It must capable of being hardened to withstand High Altitude Electromagnetic Pulse (HEMP) events and high radiation effects (residual effects of a nuclear weapon detonation is space), and be able to tolerate the space environment for up to about two hours. It should be capable of rapid steering, and provide moderate to low noise temperatures. Gain in excess of 15 dB is desired.

PHASE I: Develop a conceptual design for an electronically steerable antenna suitable for KV application. Perform modeling and simulation using commercially accepted tools to validate proposed designs and predict performance. Estimate final size, weight, and power requirements.

PHASE II: Develop and test a proposed concept design for a kill vehicle antenna.

PHASE III: Develop designs for P3I enhancements to the Ground Based Midcourse Defense Segment of Missile Defense and potential application to new systems being developed for boost and terminal phases.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The basic physical constraints for an antenna on GMD KVs apply to other Kill Vehicles (Missile Defense Agency and others), Missiles (commercial & military), and Satellites (particularly downlinks for small satellites in Low Earth Orbit). Each of these applications is also better served by an antenna that does not require physical motion to aim.

REFERENCES:

1. Hanson, R. C., Phased Array Antennas, Wiley - Interscience, 1997.
2. Fourikis, Nicholas, Phased Array Based Systems and Applications, John Wiley and Sons, 1997.

KEYWORDS: Antennas, Electronically, Steerable, Rapid, Ground, Space

MDA04-64 TITLE: Predictive Fault Detection & Isolation for Unmanned Communications Terminals

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS - MDA/GMB (GFC/C Program Office)

OBJECTIVE: Develop model-based predictive methods for detecting and isolating potential faults in electromechanical components of unmanned RF communications facilities.

DESCRIPTION: Remote radio frequency (RF) communications terminals provide essential links connecting command and control facilities with mobile elements such as in-flight interceptors, satellites, and aircraft. RF communications terminals are often deployed as unmanned facilities in regions subject to extreme weather conditions. Antenna positioning machinery, processing hardware, and environmental control subsystems in a terminal must perform reliably, over long periods of time and with minimal unscheduled maintenance, to assure mission success. Ability to predict potential future component faults and respond in advance can significantly enhance the terminal availability. The objective of the project is to develop and demonstrate model-based predictive equipment health monitoring and evaluation techniques for unmanned RF communications terminals based on advanced signal analysis and model-based trend evaluation methods. The resulting predictive techniques should operate in conjunction with conventional embedded automated fault detection/fault isolation subsystems serving terminal facilities. Monitoring techniques may utilize measurements of acoustic/vibration characteristics, observation of input electrical voltage/current waveforms, observations of the responses of solenoid actuators and servomechanisms to control signals, data logs of equipment fault summary indicators, and self-test results. Statistical pattern-recognition methods, neural networks, and qualitative analysis techniques may be employed to condition the measurements and mine long-term records for relevant features.

Evaluation techniques should apply physical, electrical, and statistical models of equipment to be evaluated (e.g., servo motors, RF coax and waveguide switches, blower motors, compressor pumps) to serve as references against which to compare data obtained from monitoring functions. Evaluation techniques must be on going and cumulative, to assess the implications of trends in monitoring results and to determine decision points at which maintenance action is to be recommended. Once monitoring and evaluation techniques are defined, they should be applied to an automated fault detection and isolation processing architecture, which will provide means for capture of measurements and integration of the conditioning and evaluation technique implementations.

PHASE I: Develop and evaluate an architecture and candidate set of models and algorithms for predictive equipment evaluation of remote RF communications terminal health, including monitoring, signal conditioning, equipment models, assessment, and maintenance decision-making. Provide a report documenting the design and results.

PHASE II: Develop and test the predictive health evaluation system applicable to an MDA remote RF communications terminal, including monitoring hardware and interfaces, monitoring and signal conditioning software, and evaluation software for use with the terminal automated fault detection/fault isolation software.

PHASE III: Prepare a user-ready version of the predictive health evaluation system, including fieldable software, interfaces, installation instructions, and user documentation. Support incorporation into IFICS Data Terminals.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The predictive health evaluation techniques can be applied to many categories of remote and/or unmanned equipment installations in industrial, telecommunications, energy, and transportation systems that contain maintainable electromechanical components.

REFERENCES:
1. M. Lebold and M. Thurston, "Open Standards for Condition-Based Maintenance and Prognostic Systems," Maintenance and Reliability Conference (MARCON), Gatlinburg, TN, May 6-9 2001.
2. K. Reichard, M. Van Dyke, and K. Maynard, "Application of Sensor Fusion and Signal Classification Techniques in a Distributed Machinery Condition Monitoring System," Proceedings of SPIE, Volume 4051, April 25-28, 2000, pp 329-336.

KEYWORDS: Prognostics; Condition-Based Maintenance; Model-Based Evaluation; Qualitative Reasoning; Statistical Pattern Recognition

MDA04-65 TITLE: <u>Adaptive/Evolving Plans and Procedures for Casualty Recovery & Battle Continuity</u>

TECHNOLOGY AREAS: Materials/Processes

ACQUISITION PROGRAM: BMDS - MDA/GMD (Ground Based Midcourse)

OBJECTIVE: Develop innovative evolving procedures, materials and training plans necessary to rapidly repair and recover the GMD system to operating condition after a casualty or disaster event.

DESCRIPTION: Casualty recovery and damage control lessons have been learned over the years from combatants engaged in aggressive battles. The GMD system is starting as a testbed and initial defensive capability that must grow and evolve. GMD must have the materials, processes and the training in order to recover from damage sustained from any natural or man-made causes and get back in or continue the defense of the homeland. This may also be considered as a serious review of current methods of national crisis management or contingency planning for the facilities and infrastructure that make up the Strategic Defense Systems. The system must provide flexibility to adapt and grow with the GMD program, while providing robust recovery options.

PHASE I: Review and rethink Threat Assessments that have already been established. Review natural events within the local region where current and future GMD assets are situated. Conduct a study that establishes and quantifies the type and degree of damage caused by these events. Check any and all backup facilities/utilities and the ease of their substitution to recover the system. Perform simulation modeling to establish range of knowns and unknowns that may be involved in system casualties. Provide a report that shows how the system would be affected, how the recovery plan adapts to situations, and how the repair & recovery plan may adapt/evolve with the growth and evolution of the GMD system.

PHASE II: Establish Comprehensive Crisis Plan, considering locations of back-ups, secondary command and control, response team composition, duties and location, and redundant emergency communications. Establish rapid damage reporting and assessment procedures, establish remediation techniques and methods. Engage local, state and federal agencies in planning and cooperating. Establish courses of action and plans in the event of a total and unrecoverable loss.

PHASE III: Implement the plan, acquire and place recovery materials, populate the recovery system, train the staff and exercise the plan on a routine basis.
PRIVATE SECTOR COMMERCIAL POTENTIAL: In addition to other elements of GMD and MDA, techniques for adaptive and growable management of large scale systems faults can be applied to many categories of emergency management including Homeland Defense, and other Federal, State, and local government agencies. These techniques could also be useful in the private sector for companies dealing with major interruptions to business operations such as earthquakes, fire, floods and acts of terrorism or war.

REFRENCES: 1. Kalt, Henry, "Assuming The Probability of Recovery," Disaster Recovery Journal, Winter 2003.
2. Pelant, B. F., "Probability or Consequence," Disaster Recovery Journal, Winter 2003.

KEYWORDS: Disaster Management; Casualty Recovery; Damage Control; Loss Management; Disaster Recovery; Improved Communications; Sustained Defense

MDA04-66 TITLE: <u>Software Modem for Kill Vehicle & IFICS</u>

TECHNOLOGY AREAS: Information Systems

ACQUISITION PROGRAM: BMDS - MDA/GMB (GFC/C Program Office)

OBJECTIVE: The objective of this program is to research innovative hardware and software technologies necessary to efficiently and cost effectively incorporate software modem technology to communications between a ground terminal and a Space Platform or Kill Vehicle through a fading channel.

DESCRIPTION: The In Flight Interceptor Communication System (IFICS) must uplink guidance information to the Exoatmospheric Kill Vehicle and downlink health and status reports. The current system uses custom ASICs for modem implementation, making it expensive and difficult to change or upgrade the waveform. The EKV is extremely constrained in size, weight, power, and time. In addition, the elements that are part of the EKV must endure extreme launch acceleration, the LEO space environment, and must be capable of being hardened to both

radiation environments and HEMP events resulting from Nuclear Weapons Effects. The RF signal must propagate thorough regions of the ionosphere affected by scintillation resulting from Nuclear Weapons Effects, which produce a fading channel that is commonly modeled using Rician and/or Rayleigh distributions. The standard model for these fading channels is specified by the Defense Threat Reduction Agency, as described in (Bogusch, 1989). This burst mode system must transfer 20K to 40K bits in 1 to 2 seconds, through Rayleigh/Rician fading channels. The system is constrained in power, not bandwidth. An effective system will probably include non-coherent demodulation, encryption, error correcting codes, and channel interleaveing. This program will research and demonstrate adaptive and robust computing & communications technologies that can adapt functionality to demands and conditions.
Technologies of interest include architectures, hardware (including processor and interface to RF hardware), programming environments, and compilers/language(s). Any software design must take into account the constraints on KV hardware in that the KV will not have tremendous computing resources to draw upon. The corresponding ground terminal is not as constrained, and in practice the system design generally puts as much of the workload on the ground terminal as is practical to offload work from the KV.

PHASE I: Describe hardware and software architecture to provide KV communications package. Demonstrate basic software implementation for fading channel operation. Document work in a report, and provide a Phase II development and demonstration plan.

PHASE II: Develop and demonstrate a communications package that is compatible with the GMD Kill Vehicle, and the IFCS Data Terminal.
PHASE III: Weaponize and transition/transfer of developed products to GMD system.
PRIVATE SECTOR COMMERCIAL POTENTIAL: This technology has potential applications in the commercial satellite and earth station fields, for VSATs, Milstar LDR, and transition/transfer of developed products to the military and commercial space communications markets.

REFERENCES:
1. Robert L. Bogusch, Digital Communications in Fading Channels: Modulation and Coding, Mission Research Corporation, Report for AFWL, AFWL-TR-87-52, April 1989

KEYWORDS: Software Modems; DSP, Error Correcting Codes; Turbo Codes; Modulation; Nuclear Weapons Effects; Fading Channels

MDA04-67 TITLE: <u>Rapid Fabrication of Mirrors</u>

TECHNOLOGY AREAS: Space Platforms, Weapons

ACQUISITION PROGRAM: BMDS - MDA/AL (AirBorne Laser)

OBJECTIVE: Develop and demonstrate methods to significantly decrease fabrication time of lightweight, stiff, meter-class optics

DESCRIPTION: Current mirror manufacturing methods achieve polished optics through a sequence of procedures from substrate manufacture to successive grind and polish steps than span years. Requirements for low-area-density, stiff optics have further complicated mirror fabrication by requiring less aggressive methods that employ more steps, e.g. the quilting problem. Each new lightweight mirror fabrication step can take weeks to months, be very cost prohibitive and require “best practice” methods developed via some trial and error process. New technologies, however, such as mandrels, backing structures, magnetorheological polishing, nano-laminate facesheets, removable mandrels, spin-casting and other advanced processing methods have shown promise at reducing the time and even cost of fabricating optics for 1m or larger telescope mirrors. The critical issue for maturing these technologies has been the lack of controlled processes necessary to meet the 20th wave figure and less than 10 nanometer roughness numbers. Further complications in this area have been that certain methods work with only certain mirror materials due to thermal or stiffness issues. New methods have also not definitively traced the technology toward some reduced schedule or cost savings given current mirror manufacturing methods. The innovation in this effort is a unique combination of material selection and fabrication process for large, lightweight optics for aerospace environments such as the airborne laser. The goal of this effort is to significantly decrease the manufacturing time of meter-class aerospace optics from years to months and weeks.

PHASE I: Identify a promising concept for the end-to-end manufacture of low-area-density optics that will be viable for the required nanometer-scale quality, 1-meter dimension, and short fabrication time; within this concept identify and investigate critical technology/ process control methods. Testing of the methods on small coupons could also be performed as a verification of the processes. The technology development effort should focus on methods that lead to quantifiable schedule and possibly cost savings for mirror production, given a current aggressive mirror manufacturing method for producing low-area-density, stiff optics. Investigation of schedule and cost savings for one such method should be explored as a small subset of the Phase I effort.

PHASE II: Continue technology development with production of a subscale parabolic article. Finalize process steps toward definitive process control. Design and conduct laboratory demonstration based performance parameters derived from a military or militarily relevant commercial application.

PHASE III: Due to the current high activity levels in both government and industry related to both the SBL and ABL programs, there are many opportunities for the advancement to a successful Phase-III program for this topic. Partnership with traditional DoD prime-contractors will be pursued towards this end. Aerospace and terrestrial optics stand to benefit from the results of this program, including military & commercial aircraft mirrors, commercial and civilian remote sensing applications, optical communications systems, ground-based telescope applications, printed circuit board photo-etching systems, automatic identification systems, scanning and dimensioning systems, environmental & gaseous emission testing systems, and inspection mirrors.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Aerospace and terrestrial optics for military and commercial applications stand to benefit from the results of this program, including aircraft mirrors, remote sensing applications, optical communications systems, ground-based telescope applications, printed circuit board photo-etching systems, automatic identification systems, scanning and dimensioning systems, environmental & gaseous emission testing systems, and inspection mirrors.

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1. Matthews, Gary, FA Carbone, P Clark, DM Mack, 2001, “Semi-rigid active mirror technology advancements,” Optical Manufacturing and Testing IV, Ed by H. Philip Stahl, SPIE Proc. Vol. 4451, p. 51-57.
2. Chen, P. C., et al, 2000, "Advances in Very Lightweight Composite Mirror Technology," Opt. Eng., Vol. 39, pp. 2320-2329.
3. Catanzaro, B., et al, 2000, "C/SiC Advanced Mirror System Demonstrator Designs," UV, Optical, and IR Space Telescopes and Instruments, J. B. Breckenridge and P. J. Jakobsen, ed., Proc. SPIE Vol. 4013, pp. 672-680.
4. Ulmer, Melville P.; Altkron, Robert I.; Graham, Michael E.; Madan, Anita; Chu, Yong S, 2002, “Production and performance of multilayer coated conic sections”, Proc. of the SPIE, Vol. 4496, p. 127-133, X-Ray Optics for Astronomy, Multi-Layers, Spectrometers, and Missions.

KEYWORDS: Lightweight; Mirrors; Manufacturing; Structures; Optics, Mirror Fabrication, Mirror Construction, Mirror Polishing, Mirror Preparation

MDA04-68 TITLE: <u>Optical Sensor for Tracking and Discrimination of Multiple Targets</u>

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: BMDS - MDA/AL (AirBorne Laser)

OBJECTIVE: Develop new optical technology(s) for tracking of multiple targets, which will lead to effective countermeasures against re-entry vehicle weapon suites.

DESCRIPTION: One of the most pressing technological requirements facing the U.S. missile-defense program is for innovative sensor systems that can track and discriminate multiple targets simultaneously. New technology developments are sought for rapid, accurate tracking of multiple targets and discrimination between warheads and decoys to launch countermeasures against. Initially ground-based, the optical sensor system should have wide-field-of-view (WFOV) characteristics and be lightweight and cost-efficient for possible implementation onto airborne and space-based platforms. This sensor technology can potentially significantly enhance the tracking of multiple targets in real-time, for example, for decoy warheads released from a ballistic missile launched with hostile intent.

Proposals are encouraged that present new technology to provide instantaneous positioning of multiple objects using sensor techniques that are an order of magnitude faster than CCD camera systems and more accurate than radar tracking, resulting in significantly faster tracking metrics.

PHASE I: Develop and demonstrate feasibility of optical sensor system design(s) using modeling, simulations and limited field testing. Develop and test scaled prototype or key system subcomponent as proof of concept. Phase I should include a plan of development for Phase II R&D and beyond.

PHASE II: Complete/finalize the build of an optical sensor system and demonstrate full scale prototype.

Phase III: Possible applications include DoD intercept missile systems. Demonstration would include, but not be limited to, demonstration in a real system or operation in a system level test-bed. This demonstration should show near term application to one or more MDA element systems, subsystems, or components.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Applications of this technology have clear commercialization potential in DoD-related markets; optical advancements will also be of interest to the civilian and academic astronomy community.

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1. Riker, J.F., “Active Tracking Lasers for Precision Target Stabilization,” SPIE Aerosense 2003, Orlando, Florida, 21-25 April 2003.
2. Merritt, P.H. and M.A. Kramer, “Active tracking of boosting missiles,” AFRL PL-TR-97-1083, May 1997.

KEYWORDS: optical, sensor, multiple target discrimination, decoy, tracking

MDA04-69 TITLE: Fine Steering Mirrors for Airborne Laser

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: BMDS - MDA/AL (AirBorne Laser)

OBJECTIVE: Develop compact fine steering mirrors (FSM) capable of greater than 5 kHz bandwidth with sub-microradian pointing accuracy in a power efficient design.

DESCRIPTION: The Airborne Laser requires high accuracy pointing systems to direct energy at missile systems during the boost phase. Fine steering mirrors are generally flat mirrors located aft of the secondary optics of a typical optical train. Mechanical beam steering mirrors are typically used to enable this accurate pointing and, because of platform vibration and jitter, they must be able to mitigate high frequency components up to several kHz. Standard voice-coil-actuated and other electro-mechanical devices are able to perform to these requirements but are typically very bulky and consume significant electrical power. Alternative technologies based on active materials, micro-electro-mechanical (MEMS) devices, or optical phased arrays are becoming available, including actuator technologies developed through the DARPA/DSO Compact Hybrid Actuator Program, and promise to offer similar performance with significantly reduced power requirements. The application of these and other technologies to airborne or spaceborne optical systems would greatly reduce the overall size and power of such systems. To this end, the development of novel compact, power efficient fine steering mirrors is solicited.

PHASE I: Examine a specific innovative FSM technology and develop a concept and design to address the requirements of sub-microradian pointing and greater than 5 kHz bandwidth useful for airborne laser and free space optical communication. Identify power and size benefits of the technology compared to state of art. If possible, a proof-of-concept prototype should be developed to verify the functional performance.

PHASE II: Further development and testing of a prototype should be completed. Optimize the device design and fabrication and deliver a prototype beam pointing system.

PHASE III: Apply fine steering mirrors in future MDA and DoD beam-steering applications such as the airborne laser.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Fine steering mirrors will support low-mass, low-power-consumption space terminals for future DoD, NASA and commercial space-to-ground and inter-satellite optical communications links. Other dual use applications include: laser radar, laser range-finding, and laser illumination.

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3. Active suppression of acoustically induced jitter for the Airborne Laser, Glaese, R.M.; Anderson, E.H.; Janzen, P.C. Proceedings of the SPIE - The International Society for Optical Engineering; 2000; vol.4034, p.151-64

KEYWORDS: Optics, Fine Steering Mirrors, Micro-Electro-Mechanical System (MEMS), Optical Phased Arrays

MDA04-70 TITLE: Acoustic Mitigation for Airborne Laser

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: BMDS - MDA/AL (AirBorne Laser), ASC/TM

OBJECTIVE: Develop acoustic mitigation technologies to reduce jitter in the Airborne Laser beamtrain.

DESCRIPTION: The Airborne Laser (ABL) is a system designed to destroy ballistic missiles during the boost phase through directed energy. The effectiveness at accomplishing this mission is enhanced by stabilizing the optical beam train through reducing beamwalk and jitter. The ABL is subjected to an adverse environment with high acoustic levels, which can couple to lightweight structures and disturb sensitive components. Optical tables and other components can be protected from the severe environmental loads during all phases of the mission, through mitigating the acoustic loads near sensitive components, such as fast steering mirrors. System optimization in terms of weight, volume, and power is desired.

PHASE I: Develop an acoustic mitigation system to reduce localized acoustic loads in a realistic Airborne Laser environment. Conduct a concept feasibility study on candidate designs. Select a design and define testing methodology. Model the conceptual design and analyze the results through comparison with lab experimentation.

PHASE II: Further refine the Phase I results by designing, developing, and demonstrating a prototype acoustic mitigation system. Define acceptable interior and exterior environments for the structure. Demonstrate the feasibility of the Phase I design and validate the increase in system-level performance through modeling and lab demonstration. Optimize the design for weight, volume, and power requirements.

PHASE III: The Phase III will develop plans for acquisition and production of acoustic mitigation systems for ABL payloads. Commercialization potential includes stabilization of optical bench components for commercial and laboratory environments.

PRIVATE SECTOR COMMERICIALIZATION POTENTIAL: Currently, there are a growing number of aerospace missions requiring acoustic applications that seek to provide a quieter ride. Mitigation of transmitted acoustic loads looms as an important component in control acoustic deposition to these payloads. Military and commercial applications include Airborne Laser, Space Based Laser, and future large aperture observation platforms, launch vehicles, and automotives.

REFERENCES:
1. Active suppression of acoustically induced jitter for the Airborne Laser, Glaese, R.M.; Anderson, E.H.; Janzen, P.C. Proceedings of the SPIE - The International Society for Optical Engineering; 2000; vol.4034, p.151-64

KEYWORDS: Acoustic Mitigation, Jitter Control

MDA04-71 TITLE: Innovative Diagnostic Components for Optical System Fault Management

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: BMDS - MDA/AL (AirBorne Laser)

OBJECTIVE: Develop Innovative Optical Components for Optical Fault Management systems for airborne and space optical applications.

DESCRIPTION: The objective of optical systems diagnostics design is most often to provide feedback for initialization and monitoring the performance and operational health of the optical system. However this approach does not collect, correlate and store all pertinent diagnostic data in a nonvolatile memory that maintenance personnel can access on demand, nor expedite the unambiguous isolation of any system or weapon malfunction to the defective part or item using innovative sensor technology. The information most important to the maintainer must be derived from the performance data.

Include in the development of the sensor data analysis tool for the Airborne Laser the capability to effectively fault detect and fault isolate, using innovative optical components, and provide this data on demand to the maintainer for the rapid correction of optical component failures. More and more optical systems are being developed and deployed, a maintenance enhancing optical integrated diagnostics system will reduce operations and support costs, while supported improving existing systems and improving specifications for procurement of future systems.

PHASE I: Define the proposed optical diagnostic component system concept, specific system requirements, and predict the performance of the proposed design. Demonstrate basic system concepts in a laboratory environment.

PHASE II: Provide a prototype component or optical diagnostic system and laboratory demonstration to mutually agreed performance parameters. Demonstration optical systems diagnostics must be capable to support ground demonstration in a government facility and be qualifiable for an airborne experiment. The prime consideration must be deliverable component system hardware and a clear demonstration of the integrated high-performance optical diagnostic component system that will demonstrate a 20-year lifetime.

PHASE III : There is tremendous growth in the use of adaptive optics , especially in astronomy. With this increase along with requirements of ABL and SBL a requirement is created for an effective optical diagnostic system and system fault management. It is expected such a diagnostic system will find an abundance of applications in the commercial and defense sectors.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The commercial market includes such areas as astronomy, communication, power beaming, and surveying.

REFERENCES: Baird and Hanes, in Kinglake, Applied Optics and Optical Engineering, vol 4, New york, Academic, 1967.

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J. C. Stover, Optical Scattering, Measurement and Analysis Bellingham, Washington, SPIE, 1995.

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KEYWORDS: Fault Detection, Fault Isolation, Optical Path Difference, Photometric terms, aberrations, Diffraction

MDA04-72 TITLE: Lightweight Modular Precision Gimbal Systems

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: BMDS - MDA/AL (AirBorne Laser)

OBJECTIVE: Assess the feasibility and develop a prototype design for an advanced modularized gimbal system design for high performance applications.

DESCRIPTION: Current sensor development efforts in the areas of threat detection and counter-weapon systems (e.g. directed energy) are requiring high resolution, rate-stabilized, two-axis gimbal systems for implementation in the field. Two primary problems exist with commercially available gimbals: (1) dealing with the inherent nonlinearity of the airborne disturbance environment and (2) the overall specific stiffness of the gimbal.

(1) Inherent nonlinearities and changing nature of disturbances (e.g. aero-acoustic loading, vibration, etc.) greatly reduce pointing and tracking control performance. Advanced control techniques (e.g. adaptive filtering and control) could be used to improve control performance. The integrating of structural damping treatments as well as variable damping devices, vibration disturbances could be mitigated and faster settling times achieved.

(2) Weight/mass issues are critical for aerospace applications. Most gimbals are fabricated using various metals, which have much lower specific stiffness than the advanced materials (such as carbon-epoxy) that are currently available. In order to provide the high stiffness between the drive motor and rotating gimbal element, relatively expensive on-axis torque motors are required for resolutions of < 10 micro-radians. A desirable alternative (for cost) is the ability to use off-axis stepper/servo motors. This approach requires driving the gimbal element through relatively flexible belt type couplings. Current belt designs have attempted to address this problem through innovative tooth design and the choice of belt materials, but their performance does not approach that of on-axis drives. It is highly desirable to develop a positive registration belt used in conjunction with off-axis control components in order to achieve pointing resolution of < 100 micro-radians, and sufficient stiffness to allow excellent dynamic responses of > 50 Hz. With operations at higher altitudes and in orbit, differential thermal expansions between the gimbal and control components manifest themselves as increased bearing torque and encoder and motor misalignment effects. Athermalized (Zero CTE) designs typically tradeoff structural stiffness when addressing increased thermal performance. By replacing conventional gimbal materials with advanced composite materials, thermal distortion throughout the optics train can be minimized. Through development of a modular series of components, a wide variety of gimbal configurations and sizes could be implemented at minimum cost and in minimum time.

Accordingly, there exists a need for a line of medium-to-high performance, composite-material, two-axis gimbals. These gimbals would provide excellent structural stiffness, low weight, and allow both on- and off-axis control technology to be implemented within the basic framework. Additionally, the use of these materials could significantly improve the performance of the drive belt technology, enabling the use of off-axis drives.

PHASE I: Conduct a feasibility analysis, prepare a Proof of Concept (PoC) design using requirements developed in meetings with AFRL and ABL personnel. The analysis shall include evidence of the vibration-isolation performance of the design.

PHASE II: Develop and demonstrate a 2nd generation design based on the lessons learned in Phase I. The 2nd generation design will be evaluated to verify that it meets the performance requirements established during the Phase I effort and is suitable for production.

PHASE III: Directed energy systems, space-based sensors, helicopters for law enforcement, robotics, and other commercial applications will benefit from this technology.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Development of a long life, vibration/maintenance free, operationally reliable sensor gimbal mount will have high DoD/NASA/Commercial demand for use with spacecraft sensors, air and ground based radar, and communication antenna applications and security surveillance equipment.

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3. Kelso, S., Denoyer, K., et.al., “Experimental Validation of a Novel Magnetorheological Isolator”, SPIE Smart Structures and Materials Conference, San Diego, CA, March 2-6, 2003.
4. R. L. Clark and K. D. Frampton, “Aeroelastic structural acoustic coupling: Implications on the control of turbulent boundary layer noise transmission,” Journal of the Acoustical Society of America 102, pp. 1639- 1647, September 1997.

KEYWORDS: Gimbals, Composite Materials, Pointing, Tracking, Adaptive Control, Damping, Vibration Suppression

MDA04-73 TITLE: Advanced Chemical Iodine Lasers

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: BMDS - MDA/AL (AirBorne Laser)

OBJECTIVE: Demonstrate innovative concepts relevant to the development of a high-energy chemical iodine laser.

DESCRIPTION: The Air Force Research Laboratory's Directed Energy Directorate (AFRL/DE) is interested in promoting and conducting innovative research on promising new technologies relevant to the development of high-energy chemical iodine lasers. The most common chemical iodine laser, COIL (Chemical Oxygen Iodine Laser), uses the highly efficient reaction between molecular chlorine and basic hydrogen peroxide (BHP) to generate electronically excited (singlet delta) oxygen. Singlet delta oxygen reacts via electronic energy transfer with atomic iodine to produce a population inversion on the I*(2P1/2) - I(2P3/2) spin-orbit transition. Provided that sufficient gain can be achieved, single line lasing at 1.3 microns is the result of the energy transfer process. Similarly, the All Gas-phase Iodine Laser (AGIL) produces singlet delta NCl that also reacts with atomic iodine to produce a population inversion.

Unfortunately, traditional COIL devices require the use of highly corrosive and bulky liquid reagents (eg. BHP) and current AGIL concepts use hydrogen azide (HN3) a highly toxic and explosive gas. These features are troublesome for both airborne and space-based applications and AFRL/DE is seeking alternative methods for generating singlet delta oxygen and/or NCl.

Potential sources of electronically excited O2 and NCl include electric discharges, alternative chemical mechanisms, optical pumping schemes, or other efficient energy transfer processes. Proposed concepts must be capable of producing high number densities of singlet delta O2, NCl, or another acceptable energy carrier.

PHASE I: 1) Define and model a promising chemical iodine laser concept or energy carrier generator. Or 2) investigate issues related to the production, storage, and usage of high densities of hydrogen azide or an alternative source of singlet delta NCl. Identify and investigate the key physical or chemical processes and arrive at a design concept.

PHASE II: Continue the effort initiated in Phase I. Design, construct, and carry out the key experiment(s) identified in Phase I. Generate an engineering design for a full scale device. Where appropriate, construct and demonstrate the full-scale device.

PHASE III: There are a number of DoD and commercial applications for COIL lasers. The development of an efficient, safe and non-liquid- based singlet-delta oxygen generator will greatly simplify the storage and handling and safety concerns of operating COIL devices. The development of a solid-state singlet-delta oxygen generator has the potential of wide application in both DoD and commercial applications and could be considered an enabling technology for proliferating the use of COIL lasers in commercial applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Possible applications include nuclear reactor decommissioning, robotic welding, and mining / drilling.

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KEYWORDS: 1. Chemical lasers 2. Directed energy weapons 3. Lasers 4. Space based lasers 5. Airborne lasers

MDA04-74 TITLE: Chemical Leak Sensors

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: BMDS - MDA/AL (AirBorne Laser)

OBJECTIVE: Develop chemical sensors specifically for CL2, NH3, I2, O2 and H2O2 with high specificity detecting the chemical it is designed for and not other chemicals.

DESCRIPTION: Chemical sensors for CL2, NH3, I2, O2 and H2O2 with high specificity detecting the chemical it is designed for and not other chemicals are needed to operate over a 3psia to 14.7 pressure range. These sensors will possess a fast response time on the order of seconds with an operational temperature range of 0 to 120 deg F and a storage range of –65 deg F to 160 deg F. The innovative sensors must be unaffected by large concentrations of the leaking chemical and operate in a relative humidity range of 5-95%. Low maintenance, long life, small, and lightweight are key characteristics of the innovative sensors.
Current state of the art chemical leak sensors are cross sensitive to other chemicals. For example, this means that large concentrations of NH3 (200ppm) will register on the CL2 detector as < 2.5 ppm level. The desired detectors must be completely insensitive to other chemicals so as not to give misleading information.

The sensors must have the ability to quickly recover from decompression. Readily available NH3 sensors take an hour, CL2 30 minutes, and H202 about 5 minutes. Faster recovery time is needed. Faster warm up times between 5-10 minutes are needed. Current sensors have long warm up periods such as: NH3 2hours, CL2 and H2O2 take 15-30 minutes. Detectors that are wireless must also be examined.

PHASE I: Define the proposed sensor concept for NH3, Cl2, I2, 02, and H2O2, specific sensor requirements, and predict the performance of the proposed sensors. Demonstrate basic sensors concepts in a laboratory environment.

Provide preliminary component analysis to show that the proposed sensors are capable of surviving an airborne environment.

PHASE II: Provide a prototype component or sensors and laboratory demonstration to mutually agreed performance parameters. Demonstration Chemical Leak Sensors must be capable to support ground demonstration in a government facility and be qualifiable for an airborne experiment. The prime consideration must be deliverable sensors hardware and a clear demonstration of the integrated high-performance sensors that will demonstrate a 20-year lifetime.

PHASE III: There is tremendous growth in the use of sensors in both space and airborne applications. With this increase along with requirements of ABL and other Laser systems a requirement is created for effective Chemical Leak sensors It is expected such sensors will find an abundance of applications in the commercial and defense sectors.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Biomedical and chemical systems are some of the dominant potential users of this technology.

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KEYWORDS: Chlorine, Basic Hydrogen Peroxide, Hydrogen peroxide, Iodine, Ammonia, Sensors

MDA04-75 TITLE: <u>Development of novel high bandwidth beam steering mirrors</u>

TECHNOLOGY AREAS: Air Platform

ACQUISITION PROGRAM: BMDS - MDA/AL (AirBorne Laser), ASC/TM

OBJECTIVE: Develop very high bandwidth tilt correction mirrors for high energy laser weapon systems.

DESCRIPTION: Airborne high energy laser weapon systems require very stable optical line of sight (LOS) control. Local jitter in these systems can span considerable bandwidth (e.g. 100s of Hz). Present alignment systems would benefit from higher bandwidth tilt correction capability. Present fast steering mirrors are reaching the limits of bandwidths, stroke, optical surface stability and reaction forces. Today alignment systems employ two types of tilt mirrors. Low bandwidth, large stroke mirrors are ganged with high bandwidth, smaller stroke mirrors. This combination of controlled mirrors can satisfy bandwidth-stroke requirements that no single mirror could achieve. To push active alignment system bandwidths higher it is proposed to introduce a third even higher bandwidth steering mirror into this chain. Offloading to lower bandwidth elements in the chain would protect the limited stroke of this new element. These new limited stroke, high bandwidth mirrors must have little reaction into mounting structures and maintain good optical figure. The following mirror characteristics are desired:

Mirror clear aperture	TBD cm
Open control loop bandwidth	TBD Hz
Tilt correction capability 500-2000 Hz	TBD power spectral density
Mirror base reaction forces	TBD % of mirror torque

PHASE I: Identify and design critical hardware components for demonstration of the mirror actuation concept. The hardware demonstration unit need not carry a full aperture mirror but the structural deformations over the full size of the mirror must be demonstrable.

PHASE II: Develop laboratory prototype hardware and demonstrate bandwidth, surface distortion and reaction force requirements.

PHASE III: There is tremendous growth in the use of optic, especially in astronomy and weapon systems. With this increase along with requirements of ABL and SBL a requirement is created for an effective optical system. It is expected such a system will find an abundance of applications in the commercial and defense sectors.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The commercial market includes such areas as laser communication and power beaming.

REFERENCE: Kenneth W. Billman, Bruce A. Horwitz, and Paul L. Shattuck "Airborne Laser System Common Path/Common Mode Design Approach", SPIE, Airborne Laser Advanced Technology II, p 196-203, Orlando Florida, 5-7 April 1999

KEYWORDS: Beam steering mirrors, active alignment systems

MDA04-76 TITLE: Accelerator for Hydrogen Peroxide Cat Bed Start

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: BMDS - MDA/AL (AirBorne Laser)

OBJECTIVE: Current catalyst beds for hydrogen peroxide take time to start. Currently heat is added to elevate the cat bed temperature and increase start time. However, maintaining a constant high temperature on the catalyst bed is a considerable long term power drain. The objective is to create a new innovative approach of cat bed rapid starting that function on a short bust of power. In order to make this concept work three challenges must be over come. 1) The system cannot consume large amounts of continuous power or be heavy. Yet the system can be charged up slowly and then operate internally at high power. 2) An adequate means of non-catalytic peroxide decomposition must created to quickly start the bed. 3) The system must "bootstrap" itself from starting to full throttle rapidly.

PHASE I: Develop the basic concept of the non-catalytic accelerator and demonstrate in small scale (test tube size) apparatus with 70%-90% hydrogen peroxide. Create a basic model of the concept and estimate scaling relationships. Develop a system schematic and parts list. Calculate the amount of power and estimate the weight of the operational system.

PHASE II: Test a sub-scale cat bed that includes the accelerator and show rapid transition from the non-catalytic start to the steady-state catalytic full throttle. Map the performance and start transient with different pressure and external temperatures. Verify key scaling parameters through testing the device. Show the device will operate predictably over a wide range condition.

PHASE III: Phase three will demonstrate a representative accelerator catalyst bed. This component will operate under conditions representative of the ABL ejector. The bed will also be demonstrated under simulated field conditions. Upon completion of testing the accelerator catalyst bed would be ready for transition to future upgrades to the ABL system.

PRIVATE SECTOR COMMERCIAL POTENTIAL: This concept could be used to enhance Hydrogen Peroxide artic diver heating and breather apparatus. The current system has difficulty starting in the artic cold. This device would enhance the current diver systems and make them more available.

In addition, Hydrogen Peroxide is being considered for use in marine batteries, due to its lack of environmental impact. This device could provide easy starting thermal power for marine systems too.

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5) "Thermal decomposition of hydrogen peroxide vapor at elevated temperatures behind incident and reflected, BILWAKESH, K R, Ohio State Univ., Columbus, PH.D. THESIS, 1969, Accession Number, N71-29624
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KEYWORDS: Hydrogen Peroxide; Decomposition; Rocket; Ejector; Catalyst Bed; Catalyst Ignition Delay; Airborne Laser

MDA04-77 TITLE: Advanced 10 Kelvin Cryogenic Cooling Component Technology

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: BMDS - MDA/SS (Space Tracking and Survellence Systems)

OBJECTIVE: Develop 10 Kelvin cryocooler component technologies for next generation spacecraft cooling applications.

DESCRIPTION: Next generation space infrared sensing technologies and spacecraft cryocooling needs will require revolutionary improvements in low temperature cryogenic cooling technology. Areas specifically targeted for improvements include highly effective, miniaturized counterflow heat exchangers, low temperature regenerators, and long life high pressure ratio DC flow compressors. Advanced heat exchangers have applications in many cooling concepts including advanced reverse Brayton coolers, Joule-Thomson coolers, and hybrid expansion cycle coolers. The enabling characteristics of the heat exchangers are high effectiveness (>0.99) combined with low pressure drop and minimal mass and volume. Regenerators are utilized in Stirling cycle based cryocoolers technologies (included pulse tube technology). Low temperature regenerators suffer from the lack of heat capacity compared to the working gas at very low temperatures. It has been demonstrated that materials with magnetic phase transitions at low temperature offer potential benefits to regenerator technology, however new improvements in material science, manufacturability, robustness, and optimum geometry still need to be explored. Long life (> 10 years, 100% duty cycle), high pressure ratio (4-6:1), DC flow (unidirectional flow) compressors are needed to enable the use of hybrid cooling systems that utilize a higher temperature cryocooler for pre-cooling and cool to low temperatures via a Joule-Thomson or other expansion cooling cycle. These key technology developments will enable future cryogenic cooling technologies and offer significant leaps in efficiency, performance, low temperature capability, and lifetime. Phase I should focus on exploitation, design, and breadboard demonstration of advanced technology with the potential for refinement in Phase II and III. Phase II and II will focus on achieving minimal to no moving parts, minimal mass, minimal input power, minimal vibration, high efficiency, and high reliability to meet emerging cooling requirements. These technologies are essential to meet future cryogenic cooling goals for increasingly compact/high density Missile Defense Agency infrared sensing payloads.

PHASE I: Phase I SBIR efforts should concentrate on the development and demonstration of the innovative technology in a breadboard format. This should include demonstration of a fundamental physical principle in a format that illustrates how this technology can be utilized in a cryocooler or as a cryocooler. This effort should include plans to further develop and exploit this technology in Phase II.

PHASE II: Phase II SBIR efforts should take the innovation of Phase I and design/develop/construct an operational prototype device or cooler. This device may not be optimized to flight levels, but should demonstrate the ability of the working prototype device to meet mutually (MDA/contractor) agreed operational specifications. Demonstration of the potential improvements in mass, input power, efficiency, reliability, and/or cryogenic system integration should be included in the effort. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort.

PHASE III: Applications of this technology could potentially be far reaching. Typical MDA and DoD military space applications relate to infrared sensing, cryogen management, electronics cooling, and superconductivity. Potential Phase III opportunities to transfer this technology to emerging MDA programs include the Advanced Space Based Infrared System and block upgrades to the Space Tracking and Surveillance System, where a number of cryocooler are planned to be built and fielded over a short build schedule.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The applications of this technology could potentially be far reaching with large market potential due to the increased reliability and expected reduction in cost for cryogenic coolers. Applications of this technology include NASA, civil, and the commercial sector for space based and airborne uses such as missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. The need for high reliability cryocoolers for terrestrial applications includes cellular bay station cooling and magnetic resonance imaging. Other potential applications include CMOS (complimentary metal-oxide semiconductor) cooling for workstations and personal computers.

REFERENCES:
1. G. E. Cruz, R. M. Franks, “MODIL Cryocooler Producibility Demonstration Project Results,” Sponsor: Department of Energy, Washington DC, Report No.: UCRL-ID-112216, 24 Jun 93, 56p. Available through NTIS at 1-800-553-NTIS; NTIS No.: DE93019213.
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KEYWORDS: Cryocooler, Space, Cryogenic Refrigerator, Regenerator, Infrared Sensors, Cryogenics, Heat Exchangers, Low Temperature, Compressor

MDA04-78 TITLE: <u>Manufacturability, Producibility, and Reliability of Space Cryogenic Cooling Technology</u>

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: BMDS - MDA/SS (Space Tracking and Survellence Systems)

OBJECTIVE: Develop processes, techniques, and technology to address manufacturability, producibility, and reliability of space cryogenic coolers.

DESCRIPTION: Lifetime and reliability are driving concerns for the use of active cryogenic cooling technology in space. Military, commercial, and scientific applications have driven the requirements for the development of long life (10+ years), high reliability cryocoolers for three decades. Although the overall scope of development issues for active refrigeration includes the mechanical cooling unit itself, the power conditioning and control electronics, and the software utilized for cryocooler operation, the current focus and greatest concern is the reliability of the mechanical cryocooler. Recent developments in the state of the art have vastly improved the current generation of cryocoolers technology, but significant issues remain and chiefly center around the reliability of the devices utilized for long life missions applications. Quantifying the lifetime and reliability of long life cryocooler technology is elusive. Many of the mechanical refrigerators that have been developed, or are under development, are usually unique or have very low production numbers (1-2 units). Additionally, designs mature and evolve from cooler to cooler to accommodate new improvements or to meeting emerging customer specification. These changes affect the design heritage and any prediction of cryocooler reliability. One large unknown in the useful lifetime prediction for cryocooler performance is the long-term degradation components that are observed only over thousands of hours of operation. Innovative proposals should address design, manufacturing, producibility, and reliability issues for components and complete mechanical cryocoolers. Issues included, but are not limited to, close tolerances, flexing elements, high precision alignment, hermeticity, gaseous contamination, component and system qualification and testing could be addressed with the overall goal of enabling verification of reliable cryocoolers for space applications.

PHASE I: Phase I SBIR efforts should concentrate on the development of the fundamental concepts for increased manufacturability, producibility, and reliability of space cryogenic coolers. This could include demonstration of a process or fundamental physical principle in a format that illustrates how this technology can be further developed and utilized in a cryocooler. This effort should include plans to further develop and exploit this technology in Phase II.

PHASE II: Phase II SBIR efforts should take the innovation of Phase I and design/develop/construct a breadboard device to demonstrate the innovation. This device may not be optimized for flight levels, but should demonstrate the potential of the prototype device to meet emerging operation specifications. Demonstration of the potential improvements in manufacturing, producibility, and reliability of space cryogenic coolers should be included in the effort. The contractor should keep in mind the goal of commercialization of this innovation for the Phase III effort.

PHASE III: Typical MDA military space applications cryogenic coolers relate to infrared sensing, cryogen managements, electronics cooling, and superconductivity. Potential Phase II opportunities to transfer this technology to emerging MDA programs include the Advanced Space Based Infrared System and block upgrades to the Space Tracking and Surveillance System, where a number of cryocoolers are planned to be built and fielded over a short build schedule.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The applications of this technology could potentially be far reaching with large market potential due to the increased reliability and expected reduction in cost for cryogenic coolers. Applications of this technology include NASA, civil, and the commercial sector for space based and airborne uses such as missile tracking, surveillance, astronomy, mapping, weather monitoring, and earth resource monitoring. The need for high reliability cryocoolers for terrestrial applications includes cellular bay station cooling and magnetic resonance imaging. Other potential applications include CMOS (complimentary metal-oxide semiconductor) cooling for workstations and personal computers.

REFERENCES:
1. G. E. Cruz, R. M. Franks, “MODIL Cryocooler Producibility Demonstration Project Results,” Sponsor: Department of Energy, Washington DC, Report No.: UCRL-ID-112216, 24 Jun 93, 56p. Available through NTIS at 1-800-553-NTIS; NTIS No.: DE93019213.
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3. Michael Rich, Marko Stoyanof, Dave Glaister, “Trade Studies on IR Gimbaled Optics Cooling Technologies,” IEEE Aerospace Applications Conference Proceedings, v 5, p 255-267, Snowmass at Aspen, CO, 21-28 Mar 1998.
4. Davis, T. M., Reilly, J., and Tomlinson, B. J., USAF “Air Force Research Laboratory Cryocooler Technology Development,” Cryocoolers 10, R. G. Ross, Jr., Ed., Plenum Press, New York (1999), pp. 21-32.
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6. Tomlinson, B. J., Glaister, D., “Potential Solutions For A Cryogenic Thermal Link Across A Two Axis Gimbal For Optics Cooling,” AIAA Defense and Civil Space Conference, Huntsville, AL (1998).
7. Nellis, G., F. Dolan, W. Swift, and H. Sixsmith, "Reverse Brayton Cooler for NICMOS," Cryocoolers 10, R. G. Ross, Jr., Ed., Plenum Press, New York (1999), pp. 431-438.

KEYWORDS: Cryocooler, Space, Cryogenic Refrigerator, Regenerator, Infrared Sensors, Cryogenics, Heat Exchangers, Low Temperature, Compressor

MDA04-79 TITLE: <u>Dynamic Spectral Filtering Techniques</u>

TECHNOLOGY AREAS: Materials/Processes, Sensors

ACQUISITION PROGRAM: BMDS - MDA/AL, MDA/SS

OBJECTIVE: Develop new active and passive spectral and spatial filtering techniques (materials and /or processing) with enhanced performance and utility for energy control, switching, and redirection.

DESCRIPTION: Liquid crystal materials are pervasive through commercial based applications ranging from simple twisted nematic-based devices to more complicated display architectures. They are also used in a number of commercial imaging, shuttering, novelty, and entertainment applications. Most of these devices take advantage of the switchable anisotropic optical properties of the LC fluid. The objective of this topic is to improve upon and exploit these properties for their application in state-of-the-art laser applications. This task necessitates that nonconventional environments (particularly those in space), configurations, and performance specifications be worked towards. Examples of research areas appropriate are new passive materials that respond to low flux levels (transmissive spatial light modulators) and new non-polarizer based agile techniques to control the optical properties across a given spectral band (dynamic filtering). Key to this is solutions with high dynamic range (large contrast), high transmission (>80%), high speed (ms or faster). Proposals submitted to this topic should focus on the materials and processing necessary to improve device performance; however, they should not be device demonstrations.

PHASE I: The offeror will demonstrate proof-of-principle with respect to a new materials or processing scheme. The offeror will demonstrate applicability and propose the issues, which must be addressed during Phase II.

PHASE II: The offeror will optimize the approach demonstrated in Phase I and will design and characterize the improved article to demonstrate advancement with respect to state-of-the-art technology.

PHASE III: Since liquid crystals are pervasive in the commercial sector, improvements to particular materials and/or processes will have wide scale applicability in numerous markets including display, entertainment, and research areas.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Commercial satellite protection, astronomy

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1. P. Drzaic, Nematic Dispersions (World Scientific, Singapore, 1995)
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KEYWORDS: agile filter, liquid crystal, dynamic spectral filtering, tunable filter, dynamic range, photo-optic

MDA04-80 TITLE: Radiation-Hardened Multijunction Solar Cells

TECHNOLOGY AREAS: Weapons

ACQUISITION PROGRAM: BMDS - MDA/SS (Space Tracking and Survellence Systems)

OBJECTIVE: Develop an innovative multijunction solar cell design with increased radiation resistance.

DESCRIPTION: Solar arrays populated by multijunction solar cells are pervasive on DOD space platforms. These arrays are sized so that the power generation performance at End-of-Life (EOL) meets the minimum power requirements of the spacecraft. The EOL power generation performance of solar arrays would be improved by the use of solar cell designs with increased resistance to radiation damage from electrons and protons of the energies found in earth orbits. These benefits would especially benefit missions in higher radiation orbits. Radiation-hardened solar cells would result in less over sizing of solar arrays to meet EOL requirements. Today's multijunction solar cells have better resistance to radiation damage compared to silicon solar cells, however exposure to high energy electrons and protons in standard LEO or GEO orbits can lead to the loss of a significant fraction of the original performance by the end of the designed lifetime of the satellite, and higher radiation orbits can lead to greater losses in solar-to-electrical power conversion performance. Coverglass can shield solar cells from low energy protons in particular, and the thickness of the coverglass can be increased to improve the shielding of the solar cells. Increased coverglass thickness adds weight and expense to solar arrays and has effective limitations. Innovative solar cell designs resulting in improved resistance to radiation damage, compared to state-of-the-art multijunction solar cells, are sought. Possible solutions include the use of semiconductor materials that have increased radiation resistance, such as InP. Other approaches could involve novel solar cell designs that minimize reductions in current as radiation damage occurs. Proposals for radiation-hardened solar cells should consider the capabilities for eventual mass production and cost of the cells.

PHASE I: Design multijunction solar cell with improved radiation resistance and demonstrate prototype (< 10 cm2) solar cell. Model of solar cell should show maximum efficiency possible for the design.

PHASE II: Demonstrate large area solar cell (> 20 cm2) and measure degradation caused by exposure to 1 MeV electron equivalent dose. Products developed in Phase II must withstand on-ground space qualification tests to insure reliable performance in space.

PHASE III: This technology is applicable to both military and commercial satellite solar arrays and is enabling for higher radiation orbits. The improved EOL power generation capabilities of this technology will have broad application in future military space systems, such as SBIR Low, GPS, MILSATCOM.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Cost-effective radiation-hardened multijunction solar cells will enable more capable systems with more massive payloads and reduced launch vehicles. This technology has application in any commercial spacecraft system and will have significant impact on both terrestrial and space applications within the consumer, commercial, and government marketplace.

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2. Summers, G.P.;Messenger, S.R.; Burke, E.A.; Xapsos, M.A. ; Walters, R.J., “Contribution of low-energy protons to the degradation of shielded GaAs solar cells in space”, Progress in Photovoltaics: Research and Applications, 5 (1997) 407-413.

KEYWORDS: Multijunction Solar Cells; Radiation Environment; Solar Arrays; Photovoltaics; Coverglass; Space Power

MDA04-81 TITLE: <u>New Concepts for Space Infrared Cryogenic Detector Multiplexers</u>

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: BMDS - MDA/SS (Space Tracking and Survellence Systems)

OBJECTIVE: Develop innovative cryogenic multiplexers for two-dimensional, infrared, staring focal plane arrays (FPA). These FPAs would be optimized for lower background applications of space-based platforms viewing either space objects or viewing ground objects through narrow spectral bandwidths.

DESCRIPTION: Innovative concepts are solicited for infrared detector array multiplexers operating at cryogenic temperatures, with emphasis on the lower backgrounds of space-based sensors viewing space targets, or down-looking sensors viewing Earth scenes through narrow spectral bandwidths. Innovation is sought in the areas of either improving total dose radiation hardness, incorporating on-FPA A-to-D conversion (with power dissipation not to exceed two hundred milliwatts for a reference 256x256 pixel FPA operating at 100 Hertz frame rate), or in interfacing to new infrared detector materials (e.g., InAs/InGaSb and related superlattice detectors) that may result in diode polarities of either “p on n” or “n on p”.

Infrared focal planes comprise an infrared detector array that is hybridized with a cryogenic detector multiplexer that is of mixed (low noise analog and fast digital) foundry processes, often with significant levels of radiation hardness. With between ten and twenty transistor elements per pixel, an example 256x256 pixel focal plane array might include over a million transistors per device. We wish to emphasize cryogenic multiplexers supporting ultra-low-levels of detector noise, such that the overall noise level in the system-level application is dominated by the random arrival of background photons, even as the background photon rate approaches levels as low as 109 photons per second per square centimeter on the device.

PHASE I: The offeror will identify objective capabilities for the new detector array multiplexer, and formulate a design meeting these objectives.

PHASE II: The offeror will translate the Phase I concept into a recipe for foundry fabrication, and fabricate (or have fabricated) the cryogenic multiplexer in accordance with the Phase I design. Partnering with a secondary source for a demonstration detector array and its hybridization with the cryogenic multiplexer is expected to result in a Phase II FPA deliverable. Teaming arrangements with larger “houses” for strategic (or lower background) infrared focal plane arrays, established in Phase II, would maximize opportunities for commercialization in Phase III. FPA(s) developed in Phase II would be delivered to the sponsor for laboratory performance evaluation.

PHASE III: Application of this technology is quite broad. Both military and other government agencies have applications for the proposed effort to include future space-based tracking, space surveillance and space hyperspectral-imaging systems.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Commercial applications include NASA remote sensing and space astronomy applications, as well as a commercial space imaging systems, surveillance, astronomy, earth mapping, weather, and earth resource monitoring. Although quite limited, there is a potential for use of this proposed effort for ground-based infrared systems that operated within radiation-enriched environments.

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1. P.R. Norton, “Status of infrared detectors”, Proceedings SPIE, Vol. 3379, pg. 102, April 1998.

MDA04-82 TITLE: Superlattice Materials for Very Long Wavelength Infrared Detectors

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: BMDS - MDA/SS (Space Tracking and Survellence Systems)

OBJECTIVE: Research and development of innovative materials and designs for semiconductor superlattices with narrow bandgaps

DESCRIPTION: The Air Force and the Missile Defense Agency require new concepts for very long wavelength infrared (VLWIR) detectors with increased operating temperature (>40K), and improved detectivity for space based applications. These detectors will be required to operate at wavelengths beyond 15 micrometers. The presently available detectors are based on extrinsic silicon. Due to excessive dark current, the operating temperature of these detectors is below 20K. Detectors with increased operating temperatures with equivalent or better detectivity will have significantly reduced launch costs due to reductions in the weight of the cryocooler. The principal alternatives to extrinsic silicon at present are compound semiconductor superlattices based on III-V elements, such as antimonides and arsenides, or II-IV elements, such as tellurides. This task seeks to develop improved and innovative epitaxial growth techniques for growing superlattices based on novel semiconductor alloy combinations such as InGaSb/InAs, HgTe/CdTe or other promising materials. These superlattice materials require controlled single crystal deposition of semiconductor layers that are less than 10 nm thick with nearly atomically abrupt changes to a different composition, and repeating this structure several hundred times. The key growth issues to be addressed are the interface abruptness and repeated control of the individual superlattice layers, materials composition, doping and thickness control. Key material issues are minimizing background carrier concentration and defect structure. Key design issues are optimized choices of superlattice layer compositions and thicknesses to achieve narrow band gaps with high IR absorption and low noise currents. Characterization of the superlattice electrical, optical or physical properties is also a major factor. Both molecular beam epitaxy (MBE) and metal organic chemical vapor deposition (MOCVD) will be considered as well as other novel growth techniques.

PHASE I: Phase I will address growth and design of superlattices along with the minimum characterization to demonstrate narrow bandgaps were achieved. A deliverable of a representative test sample to the government is encouraged.

PHASE II: Phase II will optimize the growth process and design demonstrated in Phase I with more extensive characterization and modeling as appropriate. Growth and evaluation of superlattice structures suitable for VLWIR detectors will be used to demonstrate the success of the program. Delivery of test materials to the government for evaluation is encouraged.

PHASE III: Phase III will develop and demonstrate prototype focal plane arrays with extensive focal plane test and evaluation as appropriate. Teaming with industrial focal plane suppliers is encouraged.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Structures based on semiconductor superlattices have applications in a wide variety of electronic and opto-electronic areas. Key devices with commercial markets would be room temperature operating infrared detectors, infrared lasers and microwave transistors. The technical product from this effort is expected to be high quality, hetrostructure epitaxial materials. The commercial products can either be wafers of these materials designed to user needs, or devices fabricated from these materials.

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2. C.A. Hoffman, J. R. Meyer, R.J. Bartoli, X. Chu, J. P. Faurie, L. R. Ram-Mohan, H. Xie, Journal of Vacuum Science & Technology Vol. A8, pg. 1200 (1990).

KEYWORDS: Superlattice; semiconductor materials; narrow band gap; band structure engineering; infrared detector, very long wavelength infrared

MDA04-83 TITLE: Materials and Processes for Bulk Antimony-based Substrate Materials

TECHNOLOGY AREAS: Sensors

ACQUISITION PROGRAM: BMDS - MDA/SS (Space Tracking and Survellence Systems)

OBJECTIVE: Research and development of innovative growth, surface preparation and polishing of bulk substrate materials suitable for the epitaxial growth of Sb-based superlattice LWIR/VLWIR detector material.

DESCRIPTION: The Air Force and the Missile Defense Agency require new concepts for very long wavelength infrared (VLWIR) detectors with increased operating temperature (40K), and improved detectivity for space based applications. Antimony-based strained layer superlattices have recently demonstrated potential in addressing this requirement. However, there are significant shortfalls in the preparation of lattice matched substrates available for this material system. New and innovative wafer polishing techniques are needed to address wafer planarity, surface and subsurface damage, surface contamination and surface oxides of these bulk materials. The goal of the program is to develop high quality epi-ready substrate surfaces suitable for the epitaxial growth of Sb-based strained layer superlattice materials.

PHASE I: Phase I will explore the optimal techniques for polishing GaSb wafers to produce a smooth, planar, damage free surface. If multiple techniques are proposed, an analysis of the relative merits of each technique will be performed, with characterization of surface and subsurface quality required to substantiate the findings. A deliverable of a representative wafer(s) to the government is encouraged.

PHASE II: Phase II will optimize the wafer surface preparation with more extensive demonstration and characterization with modeling of the surface chemistry used as appropriate. Growth and evaluation of superlattice structures suitable for VLWIR detectors will be used to demonstrate the success of the program. Delivery of epi-ready substrates and grown superlattice materials to the government for evaluation is encouraged.

PHASE III: Phase III will use the substrate materials developed in Phase I & II to develop and demonstrate prototype focal plane arrays with extensive focal plane test and evaluation as appropriate. Teaming with industrial focal plane suppliers is encouraged.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Structures based on semiconductor superlattices have applications in a wide variety of electronic and opto-electronic areas. Key devices with commercial markets would be room temperature operating infrared detectors, infrared lasers and microwave transistors. The technical product from this effort is expected to be high quality substrate materials suitable for epitaxial growth of superlattice detectors. The commercial products can be wafers of these materials or custom polishing services to the infrared and laser industries.

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1. "Chemical Cleaning of GaSb (1,0,0) Surfaces," L. J. Gomez-Zazo et al., J. Electrochem. Soc. Vol. 136, pg. 1480 (1989).
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3. "Advances in Chemical-Mechanical Planarization," Special Issue, MRS Bulletin, Vol. 27, October, 2002.

KEYWORDS: Superlattice; substrate materials; surface polish

MDA04-84 TITLE: Flywheel Attitude Control, Energy Transmission & Storage (FACETS) Technologies

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: BMDS - MDA/AS/SL/SS

OBJECTIVE: Develop and demonstrate Flywheel Attitude Control, Energy Transmission & Storage (FACETS) subsystem technologies that improve overall performance, life and/or operating efficiency.

DESCRIPTION: Satellite energy storage options are currently limited to a few electrochemical battery technologies. These electrochemical batteries continually demonstrate their deficiency in handling loads with high peaks or pulse power profiles, as well as any load conditions requiring high rates of charge and/or discharge. To circumvent this problem, satellite integrators are required to either de-scope their performance requirements (esp. life), or oversize the batteries with respect to the actual energy storage requirement, thus incurring a significant mass penalty. This performance deficiency of electrochemical energy storage is explained by a significant body of empirical data indicating that high rates of charge/ discharge and high depths of discharge are life-limiting factors for these technologies. On the other hand, Flywheel systems are electromechanical and are thus not life-limited by rate or depth of discharge, but only by the total number of charge/discharge cycles (fatigue). As a result, Flywheel systems will provide competitive levels of specific energy, higher rate of charge/discharge, higher depth of discharge, and higher energy transfer efficiency, as well as much greater cycle life, than conventional chemical batteries of comparable mass. Flywheels can also provide the attitude control (AC) function and replace some power management and control, resulting in decreased satellite mass since a single subsystem replaces multiple satellite subsystems. However, key components such as the bearings or suspension, rotor (rim, hub, and shaft), motor/generator, control electronics, thermal management, and the structural subsystem (casing, gimbal, etc.) currently limit the achievable performance of flywheel systems. Successful subsystem technology development should enable all sizes of space flywheel systems to life-limits of 25-30 years with usable energy densities greater than 70 W-hr/kg at the flywheel unit level (unit, electronics, thermal, etc) at greater than 95% energy round-trip efficiency. The technology should be able to facilitate simultaneous ES and AC functionality. Future space and air FACETS systems should regulate the vehicle bus at high voltage (>100 V) within +/- 2V and take advantage of the unique interface capabilities of the flywheel system over a conventional battery and AC subsystem. Innovative rotor and flywheel unit test methods are also needed to verify the capabilities of flywheel systems and subsystems for the purpose of developing and improving designs, as well as assuring the end user that the overall system will perform according to design specifications (safety and life).

PHASE I: Identify the factors of subsystem design which limit flywheel system performance. For Phase I effort, develop innovative design concepts which overcome some or all of these factors or that enable verification of flywheel subsystem capability for the purpose of overcoming these limitations. Define a Phase II program that will produce a prototype of the innovative subsystem or test method.

PHASE II: Develop a prototype of the innovative design and demonstrate that it provides the proposed benefits. Interface and collaborate with flywheel unit vendors and/or system integrators to ensure commercialization and application compatibility.

PHASE III: Team with a system integrator to implement innovative design. Primary military space and air interests are to reduce vehicle power system mass, volume, and cost in order in increase payload mass and power budgets, as well as reduce satellite and launch vehicle costs.

PRIVATE SECTOR COMMERCIAL POTENTIAL: These objectives will also benefit the commercial space and air industry. Flywheel ES technology has wide application in terrestrial power systems, such as hybrid or all electric vehicles, remote site power, and building/home secondary power supplies.

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KEYWORDS: Flywheels, attitude control, energy transmission, energy storage, FACETS

MDA04-85 TITLE: Long Life Gimbal/Bearing System

TECHNOLOGY AREAS: Air Platform, Sensors, Space Platforms

ACQUISITION PROGRAM: BMDS - MDA/AS/SL/SS

OBJECTIVE: Develop ten-year life, high reliability, ultra-smooth, fault tolerant, gimbal for slow scan sensors.

DESCRIPTION: Increasing pointing accuracy, lifetime requirements, extended environmental survivability, and other operational requirements (sensor scan rate, settling time energy/weight/vibration reduction) will eventually exceed the performance capabilities of current sensor gimbal systems. Electromechanical gimbal systems currently in use display mechanical wear, vibration, require lubricants, and have limited life. As payload functions expand the need for precise, vibration-free sensors, gimbal functionality and reliability must increase. Current limitations are partly due to the materials, components, and processes that were developed over a decade ago. An innovative, fault tolerant sensor gimbal design (including application of reliable, low-friction bearings and lubricants, if required) is needed to provide more accurate, reliable and cost effective space based sensor gimbal mounts for DOD/NASA/commercial payloads. The recent advances in electromagnetic suspension technology portend an alternative to electromechanical designs in the area of satellite sensor gimbal mounting.

Typical two-axis sensor gimbal systems are required to handle inertial loads of 5-6 IN-Lb-S2 in elevation, and 15-16 In-Lb-S2 in azimuth, be capable of active travel of +/- 185o in azimuth and -1o to +81o in elevation at an acceleration rate of 2R/S2@2R/S for each axis. Positioning error should be less than 0.005 degrees. Operational life is at least ten years. Power requirements are in the range of 3.2 Amp (Max) for the elevation axis and 1.7 Amp (Max) for the azimuth axis. Friction torque should not exceed 3 In-Lb for the elevation axis and 8 In-Lb for the azimuth axis. Structural stiffness must be capable of supporting an error signal commensurate with a 40 Hz Servo. Operational temperature span is minus forty to plus one hundred seventy degrees Fahrenheit. Materials from which the gimbal assembly is fabricated must not display outgassing characteristics greater than 1 percent total weight loss and 0.1 percent volatile condensable materials in a vacuum of 1X10-5 torr or less. The resulting two-axis gimbal system must include a lock down launch mechanism capable of withstanding 15 g's launch vibration for a period of 3 minutes. A two-axis gimbal mount design capable of meeting the above criteria should be capable of being up sized or down sized to meet additional application requirements. Successful proposals will demonstrate a thorough knowledge of the current state-of-the-art in satellite sensor gimbal designs and requirements.

PHASE I: 1) Through cooperation with the USAF, develop a thorough understanding of current satellite sensor gimbal designs versus future requirements, 2) develop a preliminary two-axis gimbal design, complete with documentation that will provide proof of functionality for high performance and long life in the space environment, 3) produce/demonstrate "small breadboard operational prototype" to ensure proof of basic design concept.

PHASE II: 1) Complete/finalize two-axis gimbal design, 2) build/demonstrate full-scale operational prototype of final design to mutually agreed upon Air Force specifications for long life.

PHASE III: Development of a long life, vibration/maintenance free, operationally reliable sensor gimbal mount will have high DoD/NASA/commercial demand for use with spacecraft sensors, air and ground based radar, and communication antenna applications and security surveillance equipment.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Gimbal/Bearing Systems have a myriad of terrestrial/commercial applications in pointing and tracking systems such as radar systems, optical systems for surveillance and imagery, etc. Improvements in these components will also increase the capability of the robotics and automation industry. The technology developed will advance the state of technology available to the commercial sector both in terms of increased capability and lifetime cost reduction of such systems.

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MDA04-86 TITLE: Low-Cost Manufacture of Lightweight Mirror Systems

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: BMDS - MDA/AS/SL/SS

OBJECTIVE: To dramatically reduce cost for low-temperature, 0.5-meter-class optical systems.

DESCRIPTION: Reducing the total manufacturing cost of 30-50cm optical telescope systems for various cryogenic applications is highly desirable. Existing and emerging technologies enable desirable area density figures of merit (<20 kg/m2), yet the cost for a 0.5-m-class primary mirror is expected to be at least $500K under the current state of the art. The manufacturing cost depends upon a complex combination of manufacturing method, polishing procedure, material, etc, and so the best method to decrease cost is unclear. Targeted for this technology are telescopes that utilize emerging mirror manufacturing concepts yet still respect needs for limited cost. The goal of this effort will be to demonstrate the technology that enables the end-to-end production of 30-50cm lightweight primary mirrors for telescopes in the cryogenic aerospace environment with optical accuracy and a cost under $200k.

PHASE I: Analyze the manufacturing cost for a complete, 0.5-m-class, advanced-technology, lightweight telescope system. Design an experiment or experimental program that demonstrates critical technology to lead to a $200k maximum total cost for manufacturing of a lightweight, concave primary mirror with minimum 0.3m diameter.

PHASE II: Continue development by building and conducting key experiments that finalize process steps toward a definitive decrease in manufacturing cost. As an end-to-end demonstration of the decreased manufacturing cost, fabricate, assemble, and cryo-test a complete prototype mirror system.

PHASE III: Due to the current high activity levels in both government and industry related to both the SBIRS-Low and ABL programs, there are many opportunities for the advancement to a successful Phase-III program for this topic. Partnership with traditional DOD prime-contractors will be pursued towards this end. In addition, while government applications will receive the most direct and immediate benefit from a successful program, terrestrial optics also stands to benefit from the results of this program.

PRIVATE SECTOR COMMERCIAL POTENTIAL: Commercial and civilian remote sensing applications will benefit from the results of this program because of the decreased cost for space-based and ground-based telescopes. The availability of cost-effective cryogenic optics may enable commercial space-based missions. Flat mirrors that may be an off-shoot of this program may be used as cost-effective steering mirrors that reduce complexity of any optical system with pointing requirements, including ground-based telescope applications, printed circuit board photo-etching systems, automatic identification systems, scanning and dimensioning systems, environmental & gaseous emission testing systems, inspection mirrors, military & commercial aircraft mirrors, commercial and civilian remote sensing applications, and optical communications systems.

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KEYWORDS: Optics, Lightweight; Mirrors; Manufacturing; Structures; Mirror Fabrication, Mirror Construction, Mirror Polishing, Mirror Preparation, Mirror cost

MDA04-87 TITLE: High Efficiency Flexible Dye-Sensitized Solar Cell for Space Application

TECHNOLOGY AREAS: Space Platforms

ACQUISITION PROGRAM: BMDS - MDA/AS/SL/SS

OBJECTIVE: Develop High Efficiency, Flexible, Solid Electrolyte Dye-Sensitized Solar Cell for Space Applications

DESCRIPTION: It is anticipated that future Department of Defense space missions will require significantly higher power levels (approaching 100 kW). To meet this need, solar arrays with high specific power and compact stowage are required. Current state of the art space solar cells are crystalline, multi-junction devices that are very complicated and costly to manufacture. Because the crystalline devices are brittle, they must be supported by honeycomb panels, which significantly limit the array specific power and increase the required stowage volume. The required stowage volume of a rigid, honeycomb array becomes a limiting factor for high power missions given the limited volume in current launch vehicle fairings. Consequently, current SOA crystalline photovoltaic devices are limited in their ability to meet the high power needs of future DoD space missions. Solid electrolyte dye-sensitized solar cells with flexible substrates (or superstrates) could be the basis for a very compact, high specific power system that could meet future high power space mission needs. The flexible nature of the devices would allow innovative array support structures, stowage, and deployment that could yield a significant increase in specific power and a reduction in stowage volume. These innovative array structures do not require heavy aluminum honeycomb panels; instead, flexible solar cells are stretched out in a “picture frame” configuration. Shape memory composites and shape memory alloys are used for array deployment and stiffness. These innovative solar arrays are currently in development for inorganic flexible thin film solar cells. Initial first order designs, with a “roll-up” stowage configuration (enabled by the flexible nature of the solar cells) , exhibit high mass and stowage efficiency (>200 W/kg vs. state of practice of ~50-70 W/kg and ~40-60 W/m3 vs. state of practice of ~10-15 W/m3). These array support structures will be directly applicable to flexible organic cells (such as solid electrolyte dye sensitized solar cells). An additional potential application for these devices is to supply power for High Altitude Airships due to their potentially high specific power and flexible nature. Typical processes for fabrication of dye-sensitized cells are less intensive than for state of the art crystalline devices; therefore, their cost is potentially much lower. Potential substrates could include very thin titanium, stainless steel, polyimide, etc. Dye-sensitized solar cells may yield higher efficiencies than other flexible thin film photovoltaic devices because of the flexibility in design provided by the demarcation of the light absorption and charge carrier transport functions.

PHASE I: Fabricate a flexible solid electrolyte dye-sensitized cell on a flexible substrate (stable AM0 efficiency ~7%). Develop design plan to fabricate a device that will survive in a space environment (high ultraviolet radiation, electron and proton radiation, and atomic oxygen).

PHASE II: Fabricate and deliver a flexible solid electrolyte dye-sensitized cell that possesses the following characteristics: (1) AM0 approaching 11%, (2) capable of surviving the space environment (device degradation caused by the space environment must be comparable to or less than that of current SOA space solar cells), (2) a specific power approaching 1000 W/kg, and (3) fabrication cost that is less than $50/W.

PHASE III: Dual use commercialization would occur through the development of high performance (high W/kg, high W/m^3, and low $/W), cells that could be used for terrestrial/space applications.

PRIVATE SECTOR COMMERCIAL POTENTIAL: The market place for commercial space based/terrestrial solar arrays is strong and growing at a rapid rate.

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KEYWORDS: Dye-sensitized Solar Cells, Graetzel Cells, Flexible Solar Cells, Polyimide Substrates, Thin Film Solar Cells, Photovoltaic Devices